

THE OHIO JOURNAL OF SCIENCE

VOL. XXXIX

SEPTEMBER, 1939

No. 5

STUDIES ON REARING THE OPOSSUM (DIDELPHYS VIRGINIANA)¹

G. E. COGHILL,
Gainesville, Florida

Scientific reports should in a sense be news. That is, they should be made promptly when the work is completed. On the other hand some things always have interest, and time does not detract from their scientific value, which may only appear after perhaps years have elapsed. Such, I believe, is the case with this report, at least with reference to certain parts which relate to records of many years standing.

During my professorship in Denison University, the Ohio Academy of Science gave me fifty dollars from the McMillan fund to defray the expenses of studying the life history of the opossum, particularly to experiment on breeding and rearing the animals in confinement. The following year it added twenty-five dollars to the grant for me to continue the work, but, while I reported my results in a paper before the Academy, I never published my findings because they seemed too incomplete at the time, and only last season did I have an opportunity to go on with the study. In making my report before the Academy I used lantern slides made from photographs, and, inasmuch as they represent phases of the life history that I have never seen illustrated photographically, some of them are reproduced in this paper.

The opossums were confined in pens—a large one to accommodate a number of animals, and small ones, sixteen feet square, for individual females. These pens were constructed of poultry netting surmounted by strips of "valley" tin. The lower edge of the wire was buried in the ground and the upper edge was made fast to the tin by means of wire loops. The tin was supported above by strong wire bound to it with wire loops.

¹This work was aided by a grant from the Josiah Macy, Jr., Foundation.

This wire and tin construction was nailed to posts, which were on the outside so that the animals could not use them for climbing. This proved to be a satisfactory fence. That is, it

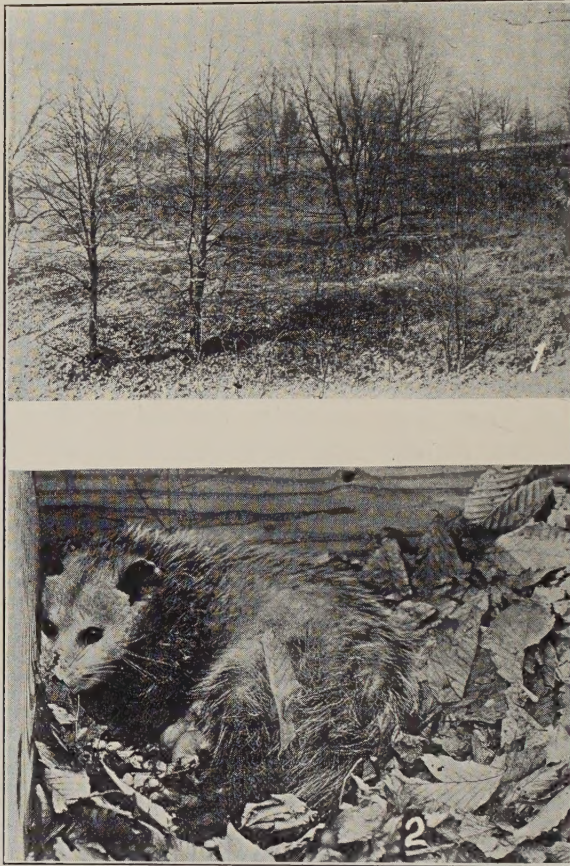


Fig. 1. The larger pen used for opossums in Granville. The fence is in view to the left of center. This shows also the natural environ preserved for the animals.

Fig. 2. A photograph of a mother opossum in the nest box from which the lid had been removed with very little disturbance of the animal. The young can be seen with their bodies outside the pouch while they still hold to the teats. The leaves of the nest were gathered and arranged in the box by the mother as they are seen in the picture.

confined the animals within the pens but it did not keep wild animals out, for they could gain entrance by climbing the posts. Pens constructed in this way, while confining the animals, gave them a close approximation to their natural habitat, in the way

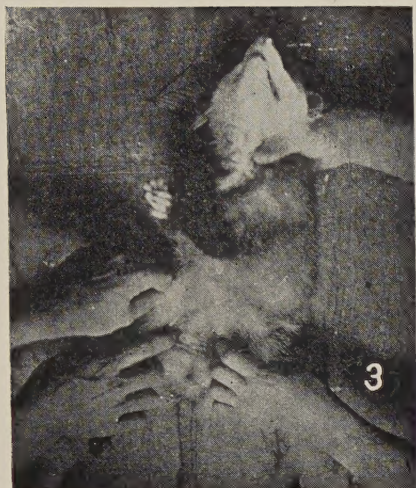


Fig. 3. A photograph of the pouch of the opossum with young of the first day. The pouch is lined with a dense coat of hair, in which the young opossums are barely visible.

Fig. 4. Photograph of the pouch and young at three weeks. The mother was held in position on the lid of the nest box for the picture.

Fig. 5. The mother and young at four weeks photographed on the lid of the nest box.

Fig. 6. The young at nine weeks photographed in the pouch.

of the fresh air of the woods and considerable freedom to move about (figure 1).

In the pens were movable nest boxes, twenty-four inches square and twelve inches high on one side and eighteen inches on the opposite side, and the roof was removable for inspection of the animals (figure 2). A door of suitable size was provided for the animals and the houses were constructed with a substantial floor to protect against moisture. In these pens and nest boxes the animals lived in a healthy condition, and young were born and reared.

In one instance copulation was observed by a competent attendant, and the gestation period was proved to be twelve days. The litter resulting from this insemination was photographed in the pouch on the first day (figure 3). This litter was photographed also at three weeks (figure 4), at four weeks (figure 5), at nine weeks (figure 6), and at ten weeks (figure 7). The young adult animal that grew up in confinement was photographed in its natural environment of the large pen (figure 8). This animal exhibited a form of nest building that, so far as I know, has never been described excepting in my report before the Academy. On an inspection tour of the pens on an autumn day I was unable to find the specimen until I noticed a conical pile of leaves which seemed too regular in form and structure to be accidental. On inspection by carefully moving the uppermost leaves to one side I discovered my opossum, which was in perfect concealment in an otherwise relatively open and exposed place. I replaced the leaves as nearly as possible as I had found them, and called the photographer. The accompanying photographs are made from lantern slides I used in my report to the Academy over twenty-five years ago (figures 9 and 10).

The purpose of my earlier work on rearing the opossum in confinement was primarily for the study of the nervous system. In my study of the cranial nerves of *Amblystoma* (1) I had found that it was possible, in specimens of appropriate age, to select a stage in which the eleventh cranial nerve is medullated when the other components of vagus ganglion through which it passes are not medullated, and by that means of differentiation I demonstrated for the first time that this nerve was actually the spinal accessory of higher vertebrates. The relatively precocious development of the eleventh nerve was the key to its identification. Therefore, it occurred to me, the relatively precocious development of the visceral sensory and motor sys-



Fig. 7. In this picture the young, photographed at ten weeks, snugly fill the pouch.

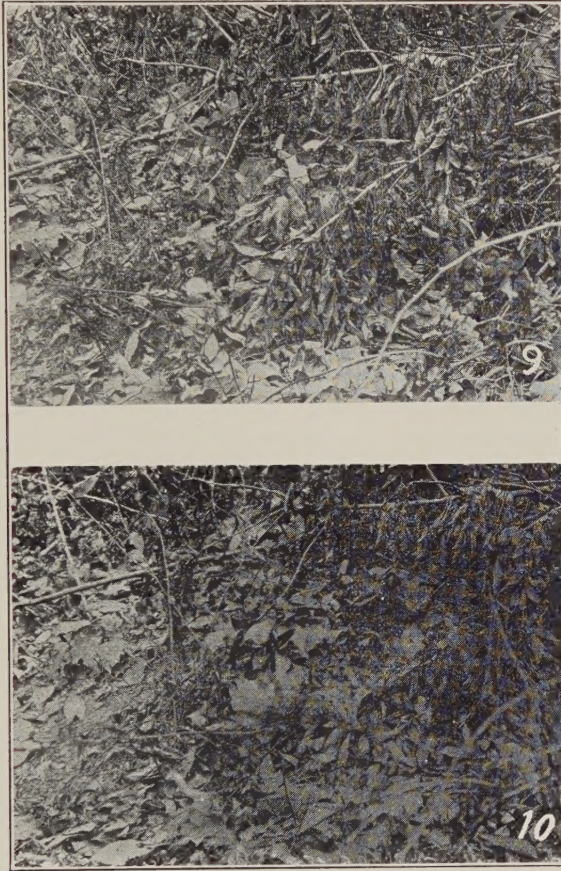
Fig. 8. An opossum thirteen months old which was reared in the pen illustrated in Fig. 1. The six-inch measure gives an idea of the size. Observe the cavern in the rocks and the natural environment.

tem in adaptation to early feeding in the opossum should enable one to differentiate these components within the brain. And with this as a point of departure I hoped to study the development of the nervous system and, possible, the development of behavior. However, I was then engaged in studies on the correlation of structure and function of the nervous system of *Amblystoma* in development, which demanded more and more of my time; and in 1913 I left the State of Ohio and had to abandon the project of rearing opossums.

Meanwhile the interest that has developed in the opossum since my experiments on rearing the animal has proved that they were timely. Since that time Hartman (2) has published his excellent studies on the development of the opossum and on the behavior of the young. He discovered that the young actually crawl into the pouch, and was first to describe the process. He was very emphatic, however, in his opinion that the opossum would not breed, at least in a satisfactory way, in confinement, and that development would not be normal if it did. Following Hartman, Rogers (3) studied the physiology of the cerebral cortex, Gray and Turner (4) studied especially the motor cortex, Langworthy and Weed (5) and Langworthy (6) investigated the brain physiologically and structurally. Also, more recently, Larsell, McCrady and Zimmerman (7) have reported on the structural development of the ear of the opossum, both with regard to the auditory and vestibular functions.

Following my residence in Ohio I had no opportunity to continue the work on the opossum till I came to Florida, where thanks to the Josiah Macy, Jr., Foundation, I was able to build pens and procure specimens for the breeding season of 1938. Again I used box-houses in the open and individual pens, but of a somewhat different design from those I used in Ohio. My housing is on the apartment plan, and the houses contain four apartments designed to accommodate one specimen each. Two houses, with the separate runways between them, form a unit. The houses are thirty inches by forty-eight inches, and the apartments, twelve inches by thirty inches, each with its hinged lid (roof) for inspection, and a door giving the animal access to the runway. The runways extend between the two houses of a unit, but are divided by a partition in the middle in such a way that the eight animals of a unit may be fed and watered at one operation. The runways are essentially tunnels made with two six inch boards for floor and two for roof, and frames

of wire cloth (one-half inch mesh) for the sides and partitions. The frames and boards are ten feet long, and the sections are held in place by suitable supports. At the adjacent ends the



Figs. 9 and 10. Photograph of the nest of the opossum which is shown in fig. 8 from directly above. The nest is not in view as a whole, so that its conical shape can not be recognized but only the top-central portion is in the field. Fig. 9 shows the original structure as nearly as I could reconstruct it after discovering its occupant. Fig. 10 shows the nest sufficiently opened to expose the head of the opossum slightly to right of center.

frames of wire cloth are held to the posts of the supports by a bolt in the middle so that there is considerable flexibility of the system in the vertical plane. The length of the runways is a multiple of ten feet, and by using an odd number of frames and

placing the partition in the middle of a section, the eight animals may be fed and watered by the removal of four boards of the roof. If desired the floor can be constructed of wire cloth and the runways elevated so that they can be cleaned with a hose. In feeding I have used successfully a well-known brand of dog food. This system of houses and runways is a success in that opossums bred in them and had healthy young, which were removed from the pouch and their behavior studied. Furthermore, a part of a litter may be removed from the pouch and the rest left for later observation.

Upon withdrawal from the pouch the young cling tenaciously to the teat (figure 11). Sometimes a drop of blood appears near the mouth, but I did not determine its source, whether from the mother or from the young. Immediately after removal from the pouch the young were placed in an incubator designed for the purpose. It is thirty inches long, sixteen inches wide and thirty inches high over all. In the upper part is a chamber for observation five inches high, covered with plate glass and with a door in front that swings down to the horizontal position and furnishes an arm rest. In the opening of the door is a curtain which drops over and around the wrists of the observer when he inserts his hands for manipulating the specimens. From the rear of the chamber a well, eighteen inches deep and five inches wide, extends the whole length of the incubator and is covered with fine wire screen. In the bottom of this well, attached to a removable floor, are electric lights as heating units. In each end of the well and chamber are three round windows which can be opened or closed at will for ventilation. The well, chamber and door are lined with insulating board.

In the incubator the young are placed on outing flannel in shallow dishes. The flannel is saturated with mineral oil, which soon covers the skin completely, due to the almost continual activity of the young, and prevents desiccation of the skin. The flannel, also, furnishes a fibrous surface on which the claws can take hold for the young to right themselves to an upright position and crawl. Under these conditions in the incubator the young of the first day after birth will live as long as seven hours, and those three days old as long as twelve hours, dying apparently from inanition. It is not certain that the young live longer in the incubator than they would at room temperature but they are much more active in the incubator. At room temperature they soon become cold to the touch and pale, and

are very inactive. Their reactions can not be normal when they are in a stupor from cold.

My interest in the opossum now centers, not primarily in the nervous system, for I cannot hope to do the requisite microscopic work, but in the development of its behavior. During the breeding season of 1938 I made exploratory studies



Fig. 11. A photograph of the young opossums being drawn forcibly from the mother. This photograph was given me by Mr. C. D. Bunker, Curator of the Museum of the University of Kansas, and is published with his permission.

which yielded definite results on a few points, particularly upon the movement of the legs and walking. A brief report of this work is published elsewhere (8), but it is appropriate here to give an account of it in greater detail.

The opossum at birth has the unusual ability of standing upright (righting reaction) on a suitable surface by thigmotactic response. This action has been known simply as a behavior pattern since the studies of Hartman, but only since the observa-

tions by Larsell, McCrady and Zimmerman has it been known that the vestibular system is not developed at this time. It cannot, therefore, be a factor in this response.

In this righting reaction the fore limbs and snout are the chief factors, and probably the snout is most important as a sensory organ for transmitting the tactile stimuli, for the young animal is constantly rooting deeply into the flannel or moving the snout from side to side high in the air as if searching for contact. The result of this behavior under natural conditions would be to find the teat in the pouch. Meanwhile the fore limbs are the chief effector agents in the righting reactions. The claws of the fore feet are very strong and catch upon any suitable object with which they come in contact, such as the hair of the mother or the fibers of a rough cloth. By this means the young can swing suspended from the under surface of flannel if the cloth on which it lies is gradually inverted. In this performance the claws of the hind feet participate, although at that time the hind foot barely projects beyond the contours of the body, and is perfectly immobile. The part that the hind feet play in the performance is, therefore, wholly passive, but that the fore feet actively take hold of the fabric is certain, for in the reaching movement of the fore leg and foot the flexion of the toes is plainly visible as the arm begins to withdraw. By this action of the limbs and claws in co-operation with the movements of the snout the young animal can right himself and walk. In the absence of the vestibular system this righting reaction and walking is purely thigmotactic.

Probably the most important thing about the behavior of the young opossum is the retarded development of the hind limbs relative to the fore limbs and head. When the young one is born, and for about a week thereafter, it can not move the hind limbs, in response either to external stimulation or to internal conditions (spontaneously). For this reason the behavior of the hind limbs, and their participation in the behavior of the whole animal, can be observed from the first in the born animal, whereas, in animals other than the marsupials, this phase of behavior can be studied only in the embryo. Furthermore, embryos are very fragile and require special methods and refined technique to be brought under observation and kept alive in a condition that approximates the normal. The young opossum, on the other hand, is easily accessible and is very hardy. The simple expedients of keeping it warm and

preventing the skin from drying are all the precautions necessary to insure lively behavior, and one can handle them roughly apparently without injuring them, so that one does not question whether or not the behavior is normal. By taking advantage of this condition I have been able, for instance, to prove satisfactorily to myself, that the hind limbs become co-ordinated with the fore limbs in the walking gait before they are capable of reflex action in response to stimulation on the foot. This means that there are two components of locomotion: the action of the total pattern, which establishes gait; and reflex action, which maintains the appropriate relation to surfaces. This is simply and directly seen in the young opossum whereas it would require special precaution and elaborate technique to see it in the embryos of Eutheria. In *Amblystoma*, however, I have definitely established this principle (9). That it applies to marsupials, also, is important to physiology.

In conclusion, the work that was begun over twenty-five years ago with the aid of the Ohio Academy of Science has been confirmed and supplemented by recent work. The opossum will breed in confinement if a close approximation to its normal habitat is maintained. Expensive buildings and luxurious laboratories are not necessary. They are, on the other hand, probably a hindrance rather than a help, in that they subject the animals to extremely abnormal environment. Simple nest houses and runways out of doors is all that is necessary.

For the excellent photographs of figures 1 to 10 I am greatly indebted to Mr. Howard Clark, who was a student in Denison University at the time of my earlier work in Granville. For the photograph of figure 11 I wish to thank my friend, Mr. C. D. Bunker, of the University of Kansas.

LITERATURE CITED

- (1) Coghill, G. E. 1902. *Jour. Comp. Neurol.* XII: 205-296.
- (2) Hartman, C. G. 1920. *Anat. Record* XIX: 251.
- (3) Rogers, F. T. 1925. *Amer. Jour. Physiol.* 63: 433; 1924. *Jour. Comp. Neurol.* 37: 265.
- (4) Gray, P. A. 1924. *Jour. Comp. Neurol.* 37: 221.
- Gray, P. A., and E. L. Turner. 1924. *Jour. Comp. Neurol.* 36: 375.
- (5) Weed, L. H., and O. R. Langworthy. 1925. *Amer. Jour. Physiol.* 72: 25.
1925. *Amer. Jour. Physiol.* 72: 8.
- (6) Langworthy, O. R. 1925. *Amer. Jour. Physiol.* 74: 1. 1927. *Contributions to Embryology*, No. 103, Carnegie Inst. Wash. Pub., Vol. XIX, No. 380, p. 149; *Contributions to Embryology*, No. 104, Carnegie Inst. Wash. Pub., Vol. XIX, No. 380, p. 177.
- (7) Larsell, O., Edward McCrady, Jr., and U. A. Zimmerman. 1935. *Jour. Comp. Neur.* 63: 95.
- (8) Coghill, G. E. 1938. *Proc. Soc. Exp. Biol. and Med.* 39: 31-35.
- (9) Coghill, G. E. 1929. *Proc. Soc. Exp. Biol. and Med.* 27: 74. 1929. "Anatomy and the Problems of Behavior" Cambridge University Press, p. 23.

THE PRODUCTION OF ACCESSORY APPENDAGES AND ANTERIOR DOUBLING IN FROG EMBRYOS BY CENTRIFUGAL FORCE

C. S. THORNTON AND R. E. ELLIS

Department of Biology,
Kenyon College, Gambier, Ohio

In looking through the literature one finds that very little work has been done on the effect of centrifugal force on the blastula of the frog or salamander. We feel that this technique may be applied with advantage to problems of amphibian experimental embryology. This belief is supported by the interesting results obtained by Banta and Gortner ('15) in centrifuging the eggs of *Rana sylvatica*. These authors found that headless monsters and tadpoles with accessory appendages were produced when eggs in the early blastopore stage were centrifuged at speeds varying from 200 times gravity to 1200 times gravity. It was in an attempt to confirm the work of Banta and Gortner and to discover whether other types of abnormalities could be produced in the frog egg by centrifugal force, that the experiments reported here were carried out.

The eggs which were used in the present experiments were of *Rana sylvatica*, and were collected in the vicinity of Gambier, Ohio, during the months of March and April, 1938. Five clusters of eggs were used, each cluster containing from 150–200 eggs. Two thirds of the eggs in each cluster were centrifuged at speeds indicated below, the remaining one third of the eggs in each cluster served as controls. The first series (cluster 1), was composed of eggs in the mid-gastrula stage and these eggs were centrifuged at 1400 r.p.m. for ten minutes. The second series (cluster 2) was composed of eggs in the late blastula stage and these were centrifuged at 1400 r.p.m. for ten minutes. The third series (cluster 3) was composed of eggs in the early blastopore stage and these were centrifuged at 1800 r.p.m. for five minutes. The fourth series (cluster 4) consisted of eggs likewise in the early blastopore stage. These were centrifuged at 2900 r.p.m. for ten minutes. Eggs in the fifth series (cluster 5) were in the late blastula stage and these also were centrifuged at 2900 r.p.m. for ten minutes.

The eggs in series I, which were in the mid-gastrula stage at the time of centrifuging, developed normally. A large per-

centage of the eggs in series II-IV, which were either in the late blastula or early gastrula stages, developed accessory appendages or anterior doubling. It is evident from these results that the egg of *Rana sylvatica* has become resistant to centrifugal force by the mid-gastrula stage. Only those eggs which were in stage 10 of Pollister and Moore ('37) ever developed abnormalities. The eggs of series V gave the highest percentage of abnormalities and it is interesting to note that this was the only series in which anterior doubling occurred. Very few eggs were killed by the centrifugal force. In all 60% of the eggs developed accessory appendages. In series V, 50% of the eggs gave rise to double monsters.

The accessory appendages which were produced were in all cases tail-like in appearance. These appendages are designated as tails although no true myotomes develop in them. Histologically these structures resemble the tail fin of a normal amphibian tail for they are composed largely of epidermis, dermis and connective tissue. These accessory tails may occur at any point on the body of the tadpole. The most common location is on the belly, but several have been observed on the dorsal side of the body just lateral to the normal tail fin. These accessory tails vary in size from tiny projections to the large structures shown in figure 1.

Banta and Gortner reported that several of the animals in their experiments which had accessory tails also had spina bifida. They found in these animals that each half of the unclosed neural groove in the posterior region of the embryo produced a tail. Similar cases have been found in our experiments and seem to be the result of the spina bifida condition. However, these cases are few in number.

In the animals possessing secondary tails on the dorsal side of the body, many cases are found in which the accessory tail fin makes a junction with the normal tail fin. An examination of the history of these cases shows that in the neurula stage a secondary and abortive neural fold had been formed which made junction with the posterior region of the primary neural folds. The neural groove later closed normally leaving a small section of neural fold tissue still connected with the neural tube and projecting at an angle from it. This section of neural fold material produced the accessory tail. This result may be correlated with the findings of Mangold ('32A) who induced the formation of a secondary tail in Triton by transplanting to an



Fig. 1 (upper). Frog tadpoles showing position and appearance of accessory tail-like appendages.

Fig. 2 (lower). Photomicrograph of a frog embryo showing two neural grooves in the anterior region. This embryo died before fixation.

early gastrula the caudal quarter of the medullary plate of a Triton neurula.

The accessory tails occurring on the ventral region of the body are harder to account for, but probably arose through the transference of a portion of the tail-forming material to that region by the centrifugal force, as has been suggested by Banta and Gortner ('15). It is interesting to note that sections show neural tube-like structures at the proximal ends of these secondary tails.

In series V anterior doubling occurred in 50% of the cases. Figure 2 is a photomicrograph of an egg showing such anterior doubling. These double monsters all died in early embryonic stages, with the exception of one case which developed into a tadpole with incomplete anterior doubling. Penners and Schleip ('28A, -'28B) have obtained similar cases of anterior doubling in the frog by inverting the fertilized egg and forcing it to develop in this position. They found that in many cases the developing blastocoel was displaced, the pressure within it causing the cells which formed its walls to present an obstacle on which the blastopore lip became split. Much the same phenomenon appears to have occurred in the present experiments but due to centrifugal force. The centrifugal force acting in the blastula stage seems to have caused a displacement of the blastocoel in such a way that the dorsal roof of the blastocoel forms a wedge upon which the invaginating dorsal lip becomes split. Each portion of the dorsal lip may then give rise to as much of a neural groove as it is capable. In the experiments reported here the splitting evidently occurred in the anterior region of the embryo and anterior doubling was thus produced. Further work on this problem is in progress.

LITERATURE CITED

- Banta, A. M., and R. A. Gortner. 1915. Accessory appendages and other abnormalities produced in amphibian larvae through the action of centrifugal force. *J. Exp. Zool.*, vol. 18, pp. 433-451.
- Mangold, O. 1932A. Autonome und komplementäre Inductionen bei Amphibien. *Naturwissenschaften*, Bd. 20, S. 371-275.
- Penners, A., and W. Schleip. 1928A. Die Entwicklung der Schütze'schen Doppelbildungen aus dem Ei von *Rana fusca*. Teil I-IV. *Zeitschr. f. wiss. Zool.*, Bd., 130, S. 307-454.
- 1928B. Die Entwicklung der Schütze'schen Doppelbildungen aus dem Ei von *Rana fusca*. Teil V-VI. *Zeitschr. f. wiss. Zool.*, Bd. 131, S. 1-156.
- Pollister, A. W., and J. A. Moore. 1937. Tables for the normal development of *Rana sylvatica*. *Anat. Rec.*, vol. 68, pp. 489-496.

THE GROWTH OF STEREUM GAUSAPATUM FRIES IN RELATION TO TEMPERATURE AND ACIDITY¹

J. ARTHUR HERRICK,
Kent State University

The recent discovery of the importance of *Stereum gausapatum* Fries as a major cause of heartrot of oaks (Davidson, 1934) served as a stimulus for a study of its general biology. The writer has attempted such an investigation and this paper represents a portion of that study.²

TEMPERATURE

The relation of the growth of *S. gausapatum* to temperature has been previously investigated. Humphrey and Siggers (1933) using temperatures from 12° C. to 40° C., report 24° C. as the optimum temperature, and 38° C. as inhibiting growth. Considerable growth took place at 12° C. *S. spadiceum*, which Burt (1920) lists as a synonym of *S. gausapatum*, was studied by Cartwright and Findlay (1934). They grew the fungus at temperatures of 5° C. to 30° C. The optimum temperature employed was 25° C. Growth was not completely inhibited at either extreme.

In the present investigation the effect of temperature on growth rate was investigated by growing the fungus at various constant temperatures ranging from 5° C. to 35° C. with 5° intervals.

About 20 cc. of potato dextrose agar was poured into each of 70 Petri plates and inoculated at one edge with a small piece of mycelium taken from the edge of a vigorously growing cul-

¹This paper is a revision of a portion of a thesis submitted to the faculty of The Ohio State University as partial fulfillment of the requirements for the degree of Doctor of Philosophy. The temperature studies were carried on at The Ohio Agricultural Experiment Station and the acidity studies at The Ohio State University.

The writer is indebted to the Department of Entomology, Ohio Agricultural Experiment Station for the use of their constant temperature chambers and to the Department of Botany and Plant Pathology, of the same institution for the use of various facilities. To Dr. W. G. Stover and other members of the Department of Botany, Ohio State University, the writer is grateful for various suggestions and criticisms.

²Two other portions of this study have recently been accepted for publication and should appear in the near future. The papers are as follows: (1) Growth and Variability of *Stereum gausapatum* Fries in Culture. To appear in *Phytopathology*. (2) A Microscopical Study of the Mycelium of *Stereum gausapatum* Fries. To appear in *Transactions of the American Microscopical Society*.

ture of a single spore isolate. In order to reduce evaporation each plate was sealed with nurseryman's tape. The cultures were kept at room temperature for 15 hours, and then ten cultures were placed in each of the various constant temperature chambers.

After six days the radius of the mycelial growth in each plate was measured in millimeters. The average growth of the ten mycelia grown at each temperature is shown in Table I.

The above experiment was repeated using malt agar with 28 cultures at each temperature and an incubation period of 10 days. The results of this experiment are also presented in Table I.

TABLE I

THE RELATION OF THE GROWTH RATE OF *Stereum gausapatum* TO TEMPERATURE AS DETERMINED BY RADIAL GROWTH OF MYCELIA AT VARIOUS CONSTANT TEMPERATURES

TEMPERATURE IN C.	5°	10°	15°	20°	25°	30°	35°
Average radial growth in mm. on potato dextrose agar in six days.....	1	3.2	5.3	27.3	44.2	32.7	2.8
Average radial growth in mm. on malt agar in ten days.....	2	10	14.4	46	73.5	66	6.5

Growth at 5° C. was very slight and probably would have been completely inhibited at some temperature between 0° C. and 5° C. The greatest growth occurred at 25° C. At 35° C. growth was very irregular and abnormal in appearance. If higher temperatures had been tried growth would probably have been inhibited at about 38° C., as reported by Humphrey and Siggers (1933).

ACIDITY

Various researches (Wolpert, 1924; Zeller, Schmitz and Duggar, 1919) have shown that many wood-destroying fungi grow best on an acid medium. Cartwright and Findlay (1934), Humphrey and Siggers (1933) and Bergenthal (1933) have all cultured this fungus on media which were acid in reaction, but there has been no work reported in which the relation of acidity to growth was investigated.

The relation of acidity to the growth rate of *S. gausapatum* has been studied by growing the fungus on potato dextrose agar having a series of pH values. One hundred fifty cc. of freshly

TABLE II

MYCELIAL GROWTH OF *Stereum gausapatum* ON POTATO DEXTROSE AGAR, HAVING DIFFERENT H-ION CONCENTRATIONS, AS DETERMINED BY RADIAL GROWTH OVER A PERIOD OF FIVE DAYS

pH Value	Number of Mycelia Measured	Minimum Radius in mm.	Maximum Radius in mm.	Average Radius in mm.
8.6	36	0	0	0.0
8.4	36	0	0	0.0
8.2	36	0	0	0.0
8.0	30	0	2	0.1
7.8	30	0	6	2.3
7.6	27	14	23	18.3
7.4	32	13	19	16.0
7.2	34	15	25	20.9
7.0	35	15	24	21.0
6.8	28	12	25	20.1
6.6	30	20	25	23.0
6.4	32	20	27	24.2
6.2	27	20	27	23.7
6.0	32	18	29	25.2
5.8	32	20	29	25.5
5.6	34	24	35	27.5
5.4	33	24	35	27.5
5.2	36	22	31	27.3
5.0	36	25	34	27.7
4.8	32	25	32	28.5
4.6	36	20	35	29.6
4.4	36	24	31	27.6
4.2	36	22	31	26.6
4.0	32	20	30	25.2
3.8	36	19	25	22.5
3.6	36	19	25	22.5
3.4	36	16	22	19.0
3.2	35	13	21	16.1
3.0	36	13	18	15.2
2.8	36	9	16	13.5
2.6	35	4	10	6.9
2.4	35	0.5	3	1.3
2.2	36	0	0	0.0
2.0	36	0	0	0.0
1.8	36	0	0	0.0

prepared potato dextrose agar was poured into each of several 250 cc. Erlenmeyer flasks. The flasks of agar were autoclaved at 15 lbs. pressure for 20 minutes, and stored for a few days. Upon remelting, the agar was found to have an acidity of pH 5.2. Suitable amounts of 5% or 20% HCl and of normal NaOH

were added to the various flasks so as to adjust the media to H-ion concentrations ranging from pH 1.8 to pH 8.6 with intervals of approximately 0.2 of a pH unit. The pH of the agar was determined by means of a Hellige comparator using color disks. Immediately after adjusting the acidity nine plates were poured from each flask. The plates were uniformly inoculated at four marginal points with a small piece of mycelium from a potato dextrose agar culture of a single spore isolate. They were allowed to incubate, in darkness, at room temperature, for a period of five days. On the fifth day the radii of the mycelia were measured in millimeters. The essential data of the experiment are presented in table form (Table II).

It may be seen from the data in this table that *S. gausapatum* will grow fairly well over a wide range of H-ion concentration. The optimum pH for growth appears to be about 4.6. As the acidity increases from the optimum, the rate of growth decreases rather uniformly. Growth is inhibited at pH 2.2. In certain preliminary experiments growth was sometimes observed to occur at pH 2.2, but never at pH 2.0. As the acidity decreases from the optimum to around pH 7.6 the growth rate gradually decreases, but a sudden drop takes place from this point to pH 8.0 or higher; beyond this point growth is inhibited. In the experiment here described almost no growth occurred at pH 8.0, but as was the case at the lower pH limit, in one of the preliminary experiments, a slight growth was observed at pH 8.0 but never at pH 8.2.

The data which are reported here for *S. gausapatum* compare favorably with such data for several other wood-rot fungi which have been previously studied (Wolpert, 1924). It is not possible to find any pH value which could justly be considered as the isoelectric point.

SUMMARY

The heartrot fungus, *Stereum gausapatum* Fries, has been grown on potato dextrose agar and on malt agar at various constant temperatures ranging from 5° C. to 35° C. Very little growth occurred at either extreme. The greatest growth occurred at 25° C.

The effect of acidity on rate of growth has been investigated by culturing the fungus on potato dextrose agar having a series of acidities. Considerable growth occurred from pH 2.8 to pH 7.6. The optimum pH for growth was found to be about 4.6.

Growth was inhibited at pH 2.2 and at pH 8.0. No indication of an isoelectric point was found.

LITERATURE CITED

- Bergenthal, W. Untersuchungen zur Biologie der wichtigsten deutschen Arten der Gattung *Stereum*. Zentralbl. für Bact. Abt. 2, 89: 209-236. 1933.
- Burt, E. A. The Thelephoraceae of North America. XII. *Stereum*. Ann. Mo. Bot. Gard. 7: 81-248. 1920.
- Cartwright, K. St. G., and W. P. K. Findlay. Studies in the physiology of wood-destroying fungi. II. Temperature and rate of growth. Ann. Bot. 48: 481-495. 1934.
- Davidson, R. W. *Stereum gausapatum*, cause of heartrot of oaks. Phytopath. 24: 831-832. 1934.
- Humphrey, C. J., and P. V. Siggers. Temperature relations of wood-destroying fungi. Jour. Agr. Res. 47: 997-1008. 1933.
- Wolpert, F. S. Studies in the physiology of the fungi. XVII. The growth of certain wood-destroying fungi in relation to H-ion concentration of the media. Ann. Mo. Bot. Gard. 11: 43-97. 1924.
- Zeller, S. M., H. Schmitz and B. M. Duggar. Studies in the physiology of fungi. VII. Growth of wood destroying fungi on liquid media. Ann. Mo. Bot. Gard. 6: 137-142. 1919.

Inorganic Chemistry

This new text for a general chemistry course should be a very teachable edition. The order of topics on matter and the kinetic theory, introducing those points of physics, which, with the first discussion on strictly chemical topics, and in essentially a descriptive form, (namely, oxygen, hydrogen, water and chlorine) leads directly and rapidly into the Periodic Classification and the Atomic and Molecular Structure. Thus, electrovalent and covalent linkages follow in natural sequence. The chemistry of carbon is introduced early in the book since those "whose major lies in some field other than chemistry usually find this more interesting than the inorganic material which it replaces. The elementary ideas of organic chemistry are no more difficult than those of inorganic chemistry." The five chapters on carbon and its compounds present an excellent summary of the fundamental simple concepts of organic chemistry and of its application in everyday life. Chapter 19 is a review and summary chapter on the material of the first half of the book and is claimed to be of great aid to the students for the semester review. Then follows series of topics covering the chemistry of the non-metals and their compounds and including other physical concepts necessary to the development of the Periodic Law. Eight chapters are devoted to the metallic elements. The last chapter is "Colloids" and is so organized that it may be introduced early in a course or eliminated entirely as the case may be. Chapter 31 is headed "Transmission Elements." Since one finds no exact definition of this term in the Chapter the conclusion could probably be reached that the term should be that more commonly used, namely, "Transition Elements." The concept of the scientific method is constantly utilized. The industrial and everyday applications of chemistry are chosen so that they may be of cultural value as well as for use in the teaching of the science. Very suitable questions are included at the end of each chapter. The text does not include any extended mathematical or theoretical discussion of certain topics such as equilibrium, but the more descriptive, qualitative discussions are apt and adequate. One finds in the word equation on page 31, "nitrate" instead of "nitrite" in the products formed, and Charles' is misspelled on page 261.

On studying the book, one feels it would be a very serviceable book for general use.—*Laurence L. Quill.*

General and Inorganic Chemistry, by Frederick C. Irwin and G. Ray Sherwood, Wayne University. x+582 pp. Philadelphia, P. Blakiston's Son and Co., Inc. 1939.

SOME FACTORS INFLUENCING ZOÖPLANKTON DISTRIBUTION IN THE HOCKING RIVER¹

LYNN HUTCHISON

Northwestern University and Ohio University

The Hocking River is located in southeastern Ohio and is a tributary of the Ohio River into which it flows about 28 miles below Marietta, Ohio. The drainage area of the river is described by Roach (1931).

The following methods and apparatus were employed during the investigation. Sixteen sampling stations were established along the river, as indicated on a map of the Hocking River (fig. 1). Stations 1 and 2, near the source of the stream, were chosen as representative of a young and unpolluted stream. Stations 3, 4, and 5 were chosen as representative of a young stream greatly polluted by organic wastes from the city of Lancaster. Stations 8, 10, and 12 represent a stream into which organic wastes are emptied from towns smaller than Lancaster and where there is a pronounced increase in the volume of water; therefore, the degree of pollution is not as great as at Stations 3 and 4 due to a decreased amount of sewage and to the dilution of the wastes. Stations 6, 7, and 9 represent a maturing stream not appreciably affected by wastes. At Station 11 the stream is polluted with mine wastes flowing in from Sunday Creek, a sizeable tributary of the Hocking. At Station 13 a dam renders the water very sluggish, although the river has not yet taken on the characteristics of an old stream. Stations 14, 15, and 16 were chosen as representative of a comparatively old stream.

Samples of water were taken from the river at these sixteen stations at intervals of one month for a period of twelve months, starting November, 1935. Samples were taken from the river about eight feet from the edge. Twenty liters of water were dipped from the river and strained through silk bolting cloth, No. 12 mesh. The residue was preserved in 10% formaldehyde.

¹The investigator is deeply appreciative of the guidance of Prof. F. H. Kreeker of Ohio University at whose suggestion the problem was undertaken; also of the aid of Dr. William Stehr of Ohio University for checking the identification of plankton organisms, and of Dr. Orlando Park of Northwestern University for criticism. This paper embodies the chief features of a thesis submitted as one of the requirements for the Master of Arts degree at Ohio University, and is contribution No. 15 from the Department of Zoölogy.

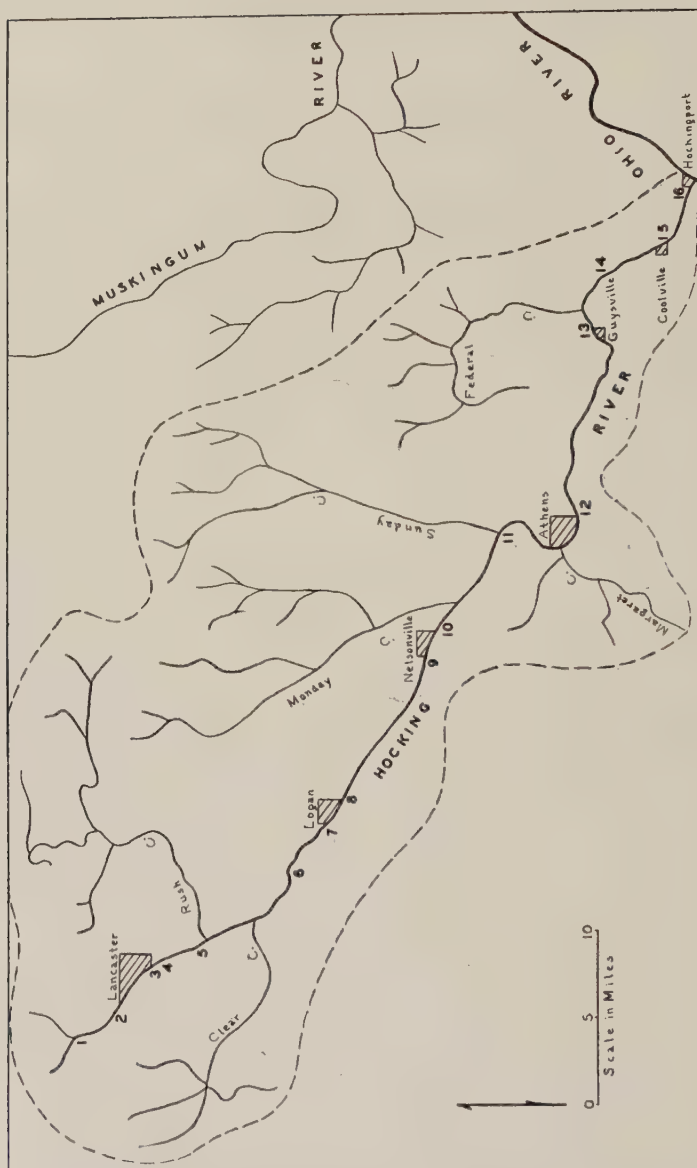


Fig. 1. Drainage area of the Hocking River. Broken line encloses the area. Numbers 1-16 indicate points where samples were taken from the river.

In the laboratory each sample was centrifuged for two minutes at a rate of 1500 revolutions per minute. A drop of the plankton which had been thrown to the bottom of the centrifuge vials was then placed in a Sedgwick-Rafter counting chamber and a quantitative and qualitative study made. As a rule, three

TABLE I
ZOOPLANKTON ORGANISMS FOUND IN THE HOCKING RIVER

PROTOZOA	*Polyarthra
Sarcodina	Pterodina
Arcella	Rattulus
Diffugia	*Rotifer
Mastigophora	Triarthra
Ceratium	* NEMATHELMINTHES
Eudorina	Nematoda
*Euglena	ANNELIDA
Gonium	Chaetopoda
*Pandorina	Chaetogaster
Phacus	Dero
Volvox	Naidium
Infusoria	Nais
*Colpidium	Limnodrilus
Paramecium	Stylaria
Stentor	Tubifex
Stylonichia	ARTHROPODA
Euplotes	Crustacea
Urocentrum	Cladocera
Vorticella	Alona
TROCHELMINTHES	Bosmina
Rotifera	Ceriodaphnia
*Anuraea	Chydorus
Asplanchnia	Daphnia
Brachionus	Pleuroxus
Cathypna	Copepoda
Diglena	Canthocampus
Diplois	*Cyclops
Monostyla	Diaptomus
*Noteus	Insecta
Notops	Chironomid larvae
Pedetes	Arachnida
Pedalion	Macrobiotus
Philodina	

*Genera represented by an average of one organism per liter of water throughout the year.

samples were examined from each centrifuged sample. Identification was limited to genera (Ward and Whipple, 1918).

The H-ion concentration was measured by the LaMotte colorimeter. Samples of water for dissolved oxygen determination were taken during the months of February, March, April, May, June, and October. These samples were obtained with

the Forest water bottle and also by immersing a sampling bottle in the water so that the water filled the bottle from the bottom upward. Determinations were carried out by the Winkler method.

Temperature of the air and water was taken at each station and recorded in degrees Centigrade. A record of the daily river height, precipitation, and temperature at Athens, 65 miles from the source of the river (Station 12) was obtained from the Athens Weather Bureau for the period of time under investigation.

THE PLANKTON

Fifty-two genera of zoöplankton organisms representing five phyla were identified during the investigation. The classification of these organisms appears in Table I. Of these, only eight genera were represented by an average of one organism per liter of water throughout the year. An asterisk has been placed before these eight genera in the classification table.

THE LONGITUDINAL DISTRIBUTION OF PLANKTON

The quantitative distribution of the plankton at the various stations is shown in Table II. At the bottom of this chart is a total of the number of genera represented by the occurrence of one or more individuals per liter of water at each station during the investigation. The greatest number of genera represented by more than one individual per liter was found at Stations 3, 4, 12, 13, and 14; Stations 5, 11, 15, and 16 rank next; Stations 6, 7, 8, 9, and 10 were represented by still fewer. At Stations 1 and 2 no genus was represented by more than one individual per liter.

Considering the average number of plankters per liter of water, as shown in Table III, it was found that Stations 3, 4, 12, and 13 were most abundantly populated, with an average of more than 80 plankters per liter of water. Stations 5, 8, 14, and 15 ranked next. Stations 6, 7, 9, 10, 11, and 16 were populated by an average of less than 21 individuals per liter. Stations 1 and 2 rank lowest.

Combining the results of these two aspects of quantitative distribution, namely, the number of genera represented by more than one individual per liter and the average number of plankters per liter, it will be seen that Stations 3, 4, 12, and 13 are indisputably the most abundantly populated, while at Stations 1 and 2 plankters were least abundant.

A compilation of the physical and chemical data, excluding the amount of dissolved oxygen and the H-ion concentration,

TABLE II
COMPOSITION OF THE PLANKTON LONGITUDINALLY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Arcella.....	-	-	-	-	-	-	-	-	-	x	x	xx	xx	xx	x	x
Colpidium.....	-	-	xx	xx	xx	x	xx	xx	xx	xx	xx	xxx	xx	-	x	x
Diffugia.....	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-
Eudorina.....	.	.	.	.	-	-	-	-	.	-	.	.	xx	xx	xx	x
Euglena.....	-	-	xxx	xxx	x	x	xxx	xxx	xxx	xx	xx	x	-	-	.	-
Pandorina.....	-	-	-	.	-	-	-	-	x	x	xx	xxx	xxx	xxx	xxx	-
Paramecium.....	-	-	xxx	xx	xx	-	-	-	-	-	-	-	-	-	-	-
Stentor.....	.	-	-	xx	x	-	-	-	.	.	.	.	-	.	.	.
Euplotes.....	-	-	-	x	-	-	-	-	-	.	-	-	-	.	.	.
Vorticella.....	-	-	-	xx	x	x	-	-	-	-	-	-	-	-	-	-
Anuraea.....	-	-	-	-	.	-	.	-	-	-	-	x	xx	xxx	xx	xx
Brachionus.....	-	-	-	-	x	-	-	-	-	-	-	xx	xx	xx	x	x
Cathypna.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monostyla.....	-	-	.	-	.	-	.	-	-	.	.	-	-	xx	-	-
Noteus.....	-	-	.	.	-	-	.	-	-	-	-	xx	xxx	xx	xx	xxx
Notops.....	-	.	-	-	-	-	-	-	-	-	-	x	xx	x	-	-
Philodina.....	-	-	xx	xx	xx	x	-	-	-	-	-	-	-	-	-	-
Polyarthra.....	-	-	.	.	.	.	.	-	-	-	xx	xxx	xxx	xx	-	.
Pterodina.....	-	-	-	-	-	-	-	.	-	-	-	-	.	-	.	-
Rattulus.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rotifer.....	-	x	xxx	xxx	xxx	xx	xx	xx	x	x	xx	xx	xx	x	x	xx
Triarthra.....	-	-	-	.	-	-	-	-	.	-	-	x	-	-	.	-
Nematoda.....	-	x	xx	xx	x	x	x	x	-	-	x	xx	xx	x	x	-
Annelida.....	-	-	-	-	-	-	-	.	.	.	-	-	-	.	-	-
Cladocera.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copepoda.....	-	-	-	-	-	-	-	x	x	x	x	xx	xx	xx	xx	xx
Insecta.....	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
Genera with more than one indi- vidual per liter.....	0	0	6	8	4	2	2	3	2	2	5	9	12	10	5	4

xxx More than five individuals per liter.

xx One to five individuals per liter.

x Five-tenths of one to one individual per liter.

- Less than five-tenths of one individual per liter.

. Absent.

as it appeared at each station, is included in Table III. An analysis of these factors follows.

The Hocking River, although not as rapid a stream as a number of others in the state, moves along without marked retardation over most of its course. Only at Station 13, where

its flow is retarded by a dam, and at Station 16, where it empties into the Ohio River, does the river become sluggish. At station 13 there were, on an average, eighty plankters per liter of water. However, with this exception, there is no pronounced increase in the average number of plankters in the lower portion of the river where the flow is somewhat retarded as compared with its rapid flow in the upper portion (Table III).

The temperature in the lower portion of the stream averaged slightly higher than the temperature at the stations near the

TABLE III
PHYSICAL AND CHEMICAL FACTORS AS THEY OCCUR AT EACH STATION

Stations	Rate of Flow Determined by Topography	Yearly Averages of Temperature of Water	Age of Stream	Average Plankters Per Liter
1	Rapid	12.0° C.	Young	2.0
2	Rapid	14.3° C.	Young	2.5
3	Rapid	14.8° C.	Old	345.0
4	Rapid	14.5° C.	Old	194.0
5	Rapid	13.5° C.	Mature	27.0
6	Rapid	13.8° C.	Adolescent	10.0
7	Rapid	13.7° C.	Mature	21.0
8	Rapid	14.2° C.	Old	40.0
9	Rapid	14.8° C.	Mature	20.0
10	Rapid	14.7° C.	Adolescent	8.5
11	Rapid	14.0° C.	Adolescent	15.0
12	Retarded	14.9° C.	Old	94.0
13	Sluggish*	15.4° C.	Old	80.0
14	Retarded	15.0° C.	Old	40.0
15	Retarded	15.2° C.	Mature	28.0
16	Sluggish†	16.1° C.	Mature	17.0

*Dam.

†Backwater.

source of the stream. It is apparent that the higher temperature and the abundance of plankters per liter in the lower portion of the river correlate closely (Table III).

"Old" age of the stream, in the sense used in Table III, refers to any region of the river where it becomes productive, as indicated by the great increase in the number of plankters. Regions where the stream was not productive were designated as "young," "adolescent," or "mature" regions, depending on the number of plankters present. It has been pointed out that the plankton was abundant at various stations in the lower half of the river; therefore, those regions were designated as being old. A somewhat retarded rate of flow and higher temperature

can be correlated with the productivity at these stations. Furthermore, Stations 3 and 4 were highly productive; therefore, they too might be considered as old regions of the stream. Retarded rate of flow and higher temperature of water cannot be correlated with the productivity at these stations. It will be recalled, however, that at Station 3, just below the city of Lancaster, the river receives a great amount of domestic sewage. Again, at Station 8, below the town of Logan, and at Station 12, just below the city of Athens, a large amount of domestic sewage is emptied into the river. Here, too, are productive regions of the river. Therefore, it seems apparent that a region may be rendered productive by addition of domestic sewage. In fact, such addition seems to counteract detrimental effects of rapid rate of flow and lower temperature as found at Stations 3 and 4. Sewage probably stimulates productivity directly by acting as food, and indirectly by rendering conditions favorable for increases in bacteria which in turn act directly as food.

The productivity of the river at Station 10, below the town of Nelsonville, is an exception to the statement that organic wastes act as stimulators of productivity. However, the influence of mine and brick plant wastes can, in all probability, account for this deviation.

The dissolved oxygen content of the water was lowest at those stations where the greatest number of organisms occurred and where sewage disposal was greatest. This might be expected, for the greater the number of organisms present, and the greater the amount of sewage, the more oxygen consumed.

The H-ion concentration varied so slightly throughout the course of the stream that effects were not apparent.

The qualitative distribution of the plankton genera appearing most abundantly is indicated by fig. 2. The figure shows that certain forms were more characteristic of some portions of the river than of others. Forms such as *Paramecium*, *Stentor*, *Euplotes*, *Vorticella*, and *Philodina* seem to be characteristic of the upper portions of the stream, especially at Stations 3, 4 and 5. Forms such as *Arcella*, *Eudorina*, *Pandorina*, *Anuraea*, *Brachionus*, *Noteus*, *Polyarthra*, *Copepoda*, and insect larvae appeared more often in the lower portions of the stream, Stations 11 to 16.

Since Stations 3 and 4 are rendered productive, quantitatively speaking, by domestic sewage, it seems probable that the

qualitative nature of the distribution at those points is also, at least in part, determined by pollution. Forms such as *Stentor* and *Euplotes* were found to be present in this region of the

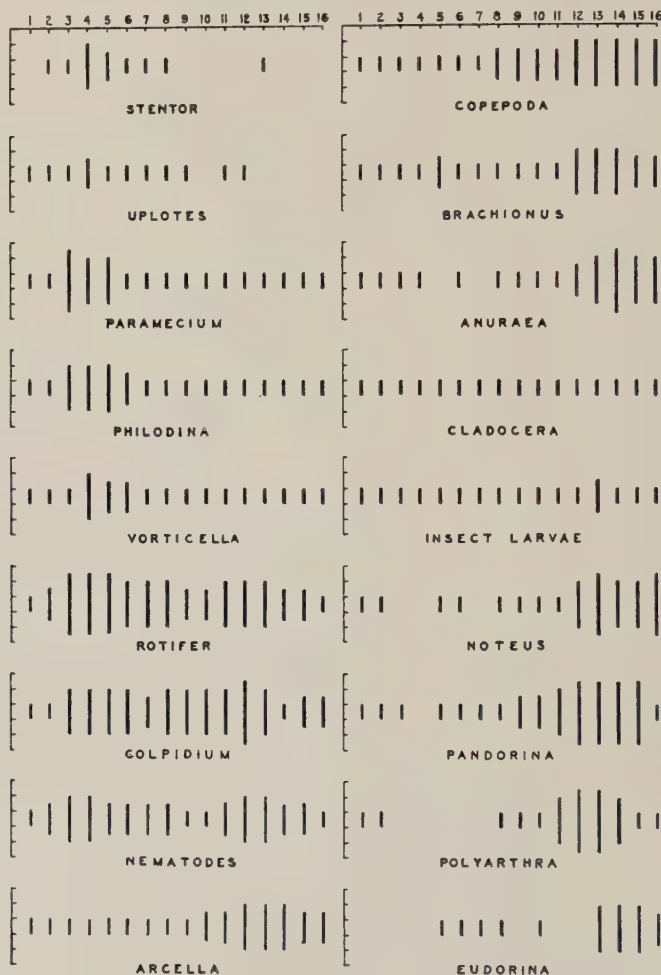


Fig. 2. Qualitative distribution of zooplankton organisms.
 — less than five tenths of one individual per liter.
 — five tenths to one individual per liter.
 — one to five individuals per liter.
 — more than five individuals per liter.

stream and to disappear entirely in the lower regions. In addition, *Paramecium*, *Philodina*, and *Rotifer* might be considered as abundant forms in regions of high sewage concentration. On the other hand, forms such as *Polyarthra* and *Eudorina* were

never found in this region where sewage was concentrated. However, they appeared in great numbers at Station 12 where the amount of sewage disposed is great; but it must be kept in mind that the concentration of pollution at that station is greatly altered by an increase in the amount of water. The river is approximately three times as wide and four times as deep at Station 12 as at Station 3.

Following a model by Wiebe (1927), Table IV has been made, the purpose being to indicate, by numbers representing abundance, the qualitative distribution of zoöplankters with reference to degree of pollution. It can be stated that these results correspond favorably with those of Wiebe.

TABLE IV
MOST ABUNDANT ZOOPLANKTERS AT EACH GROUP OF STATIONS

Genus	Group I Rank	Group II Rank	Group III Rank	Genus	Group I Rank	Group II Rank	Group III Rank
Arcella.....	3	2	2	Anuraea.....		2	1
Eudorina.....		2	1	Brachionus.....	3	2	2
Euglena.....	1	1	2	Noteus.....		2	2
Pandorina.....		1	1	Notops.....	3	2	2
Colpidium.....	2	2	2	Philodina.....	1	2	2
Paramecium.....	1	2	1	Polyarthra.....		2	1
Stentor.....	4			Rotifer.....	1	2	2
Nematode.....	2	2	2	Cyclops.....	3	2	2

Group I—Extremely polluted stations 3, 4, and 5.

Group II—Moderately polluted stations 8, 10, 12, and 13.

Group III—Comparatively unpolluted stations 6, 7, 9, 11, 14, 15, and 16.

Rank 1—very abundant; Rank 2—present; Rank 3—scarce; and Rank 4—present only in one portion.

Degree of pollution can be considered, then, as a factor partially responsible for both the quantitative and qualitative distribution of plankton along the course of the Hocking. Retarded rate of flow, size of stream as influencing degree of pollution, and higher temperature must also be considered as partially responsible for distribution, especially of such forms as *Pandorina*, *Polyarthra*, the cladoceran *Chydorus*, and insect larvae.

DISTRIBUTION BY MONTHS

Figure 3 shows that the plankton was more abundant during the summer and autumn months (June to December), than during the winter and spring months (December to June). The

months during which conditions were apparently most favorable for various plankters were:

PHYLUM	MONTHS
Protozoa.....	June, August, September
Rotifera.....	June, August, September
Annelida.....	June, November
Arthropoda.....	June, September, November

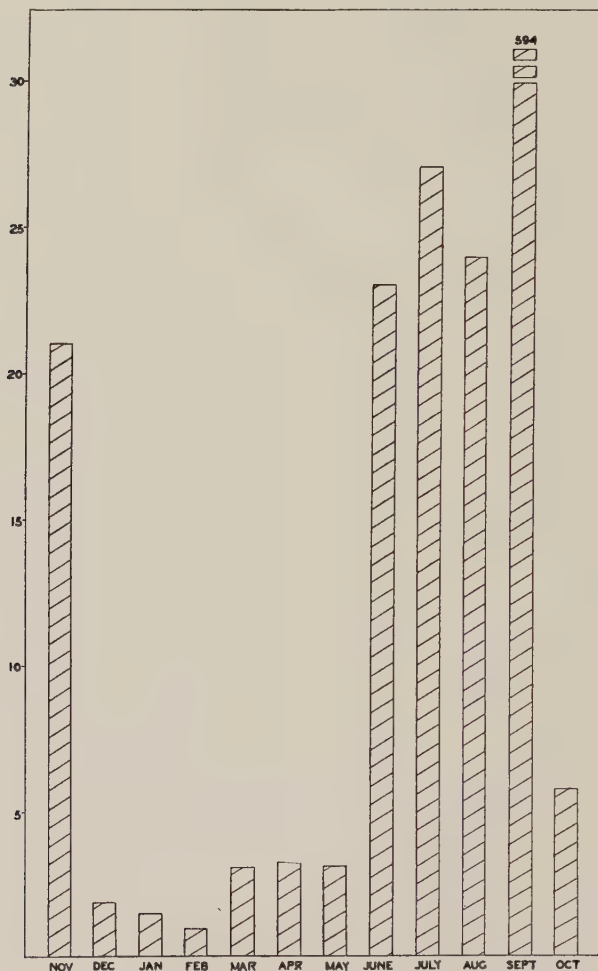


Fig. 3. Monthly distribution of zooplankton. The number of individuals per liter is indicated on the ordinate.

The monthly distribution of the plankters is shown in Table V. This table and figure 3 illustrate that minimum production occurred at times of low temperatures. Water tem-

peratures were lowest in the months of January and February, averaging 4.0° C. and 4.5° C. respectively, and highest in the month of July, averaging 27° C. Figure 3 shows that the smallest numbers of organisms were present during the months of

TABLE V
DISTRIBUTION OF PLANKTON BY MONTHS
(Individuals per Liter)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Arcella.....	2.3	0.1	—	—	0.3	0.1	—	0.4	0.4	0.3	3.9	0.1
Colpidium.....	—	—	—	—	—	.4	.1	—	21.8	.2	.1	—
Diffugia.....	—	—	—	—	—	.9	—	—	.9	.2	.2	.6
Eudorina.....	—	—	—	—	—	—	—	—	—	6.6	—	—
Euglena.....	.1	—	—	—	—	—	—	.3	—	.2	340.0	.1
Gonium.....	—	—	—	—	—	—	—	—	—	.8	1.0	—
Pandorina.....	—	—	—	—	—	—	—	—	.4	—	65.6	—
Paramecium.....	.7	.2	—	—	—	—	.1	4.0	.5	.2	1.1	—
Stentor.....	—	—	—	—	—	—	—	1.0	.1	.1	.6	—
Euplotes.....	.2	—	—	—	—	—	—	.6	—	—	—	—
Vorticella.....	.4	.1	—	—	.5	.9	.3	.7	—	—	.6	.1
Anuraea.....	.1	—	—	—	—	—	—	—	—	—	14.5	—
Brachionus.....	1.7	—	—	—	—	—	.2	.5	.7	1.0	2.4	.2
Monostyla.....	—	—	—	—	—	—	—	—	—	—	.9	.2
Noteus.....	.5	—	—	—	—	—	—	—	.4	10.0	5.7	—
Notops.....	.9	—	—	—	—	—	—	—	—	—	2.2	—
Philodina.....	.5	.1	.1	—	.1	.1	.2	4.7	—	.7	.5	.2
Polyarthra.....	—	—	—	—	—	—	—	—	—	—	50.2	—
Pterodina.....	.6	—	—	—	—	—	—	—	—	—	—	—
Rotifer.....	2.9	.5	.3	.1	.3	.1	.7	9.5	.1	2.8	104.0	2.5
Triarthra.....	—	—	—	—	—	—	—	—	—	—	.9	—
Nematoda.....	2.1	.3	.7	.7	1.2	.5	.7	.3	—	.3	.4	.7
Annelida.....	.1	—	—	—	—	—	—	—	—	—	—	—
Cladocera.....	.8	.1	—	—	—	—	—	—	.2	—	—	.1
Copepoda.....	5.6	.3	.1	—	.3	.1	.2	1.3	.5	.5	1.0	.6
Chironomidae....	1.3	.1	—	—	—	—	—	.1	—	.1	—	.1

— present in numbers less than one-tenth per liter.

January and February, and that the numbers present in July were exceeded only by the numbers present in September when the temperature had not decreased sufficiently to affect plankton productivity. Actually the plankton of February is approximately four per cent of that present in July.

On the basis of data obtained from the Athens Weather Bureau, an attempt was made to correlate stability of hydro-

graphic conditions with abundance of organisms at Station 12, situated at Athens. The results showed that the periods of greatest productivity, both quantitatively and qualitatively, occurred during those months, June, July, August, and September, when hydrographic conditions were most stable. The abundance of organisms in November is an exception to this statement but may be explained by the fact that, during that month, sampling was done the day following the first heavy precipitation for approximately a month. Such a precipitation, according to Kofoed (1903), flushes the back waters and tributaries of their plankton, thereby increasing the numbers in the main stream.

DISTRIBUTION BY SEASONS

All plankton occurred more abundantly during the autumn than during any other season. It was interesting to note that the nematodes were least abundant during the summer season. The approximate ratio between the total number of organisms per liter of water during the fall season and the other seasons is as follows:

SEASONS	RATIO	PERCENT
Fall to Winter.....	208 to 1.5.....	$\frac{3}{4}\%$
Fall to Spring.....	208 to 3.0.....	1%
Fall to Summer.....	208 to 25.0.....	12%

Evidence has already been given concerning the effect of low temperatures on monthly plankton distribution. Therefore, the small number of forms present in the stream during the winter season can be ascribed to the effect of temperature. The comparatively small increase in the number of forms during the spring is probably due to the detrimental effect of floods which occurred Feb. 16 and 27, March 22, and April 8.

ECOLOGICAL SUCCESSION

An interesting succession of genera occurred at Stations 3, 4, 5, and 6. These stations demonstrate the progressive change of the nature of the stream from an extremely polluted condition to an unpolluted condition. At Station 3, the genera *Euglena*, *Paramecium*, and *Rotifer* occurred abundantly during the entire year. *Stentor*, *Vorticella*, and *Philodina* reached their greatest abundance at Station 4. The nature of the water at Station 5 seemed favorable for *Colpidium*, the numbers of which had increased gradually since Station 3. *Pterodina* and *Chaetogaster* also occurred abundantly at this station. At Station 6 *Volvox*

appeared. This is one of the three stations at which it did occur in the entire stream. *Monostyla*, *Noteus*, *Bosmina*, *Chydorus*, and *Diaptomus* increased markedly at Station 6 in contrast with the reduction they suffered below Station 2. *Eudorina* appeared frequently for the first time at Station 6. *Euglena*, *Paramecium*, *Stentor*, *Euplotes*, *Vorticella*, *Philodina*, and *Rotifer* had decreased considerably in numbers here. It is evident that a change in the polluted nature of the river is accompanied by a change in the occurrence of plankters. Forms which occurred abundantly in the comparatively polluted region of the river gradually declined in numbers, while forms which were present before the river became polluted reappeared after the river had become relatively unpolluted.

DISCUSSION

Domestic pollution as a factor determining the qualitative distribution of plankton was included in this paper with a great degree of caution. The results of investigations are not in agreement as to the role, whether active or passive, played by pollution in lotic environments. Roach (1931) in his investigation of the plankton of the Hocking River, discards domestic pollution as an active determining factor in the distribution of plankton. However, Forbes and Richardson (1919), Wiebe (1927), and the report on pollution in the survey of the Genesee River System of New York (1927), support the active role of pollution. In the present investigation the succession of plankton organisms from Stations 3 to 6 accompanying the very profound change from septic tank conditions to clear water, and the occurrence of certain genera in the profoundly polluted regions of the stream, but not elsewhere, indicates that pollution is an active factor in determining the quality of plankton. In terms of quantity, the fact that at Stations 3 and 4 the sewage renders the Hocking productively old before it can become old according to Shelford and Eddy's (1929) statement that water in the Sangamon River was not productive till twenty days old, seems to necessitate consideration of pollution as an active factor in production in the Hocking. This view is supported by Lackey (1938) who, upon investigating factors affecting the distribution of Protozoa, found pollution to be an active factor in quantitative and qualitative distribution.

In general, the results of this investigation are in close agreement with those of other investigators of lotic environments. Kofoid (1903), Allen (1920), and Galtsoff (1924) have

pointed out that a retarded rate of flow is effective in rendering a portion of a stream productive. In the Hocking River the productivity of Station 13, a more slowly moving portion of the river, has been considered due, at least in part, to the retarded rate of flow. However, the investigator, like many others, fails to correlate the decrease of organisms at the last two stations.

The negative correlation between dissolved oxygen and plankton abundance might be expected since at no time did the dissolved oxygen content become less than 3.0 cc. per liter. Welch (1935) states that many animals do not show evidence of response to declining oxygen until it has been reduced to 0.2 or 0.3 cc. per liter, and Kofoid (1908) noted that there was no correlation between seasonal chemical and plankton flux. Both of these statements substantiate, more or less, the above dissolved oxygen and plankton relationship.

Kofoid (1903), Roach (1931), and Reinhard (1931) have described the detrimental effects of floods, the beneficial effects of hydrographic stability, and the effect of tributary plankters on plankton production. Hydrographic stability and flood effects have been noted in the present investigation as vital factors in seasonal and monthly distribution of plankton. The abundance of plankton in the main stream during November has been attributed to the washing in of tributary plankters following heavy precipitation.

The correlation between high temperature and increased plankton production need not be discussed. The fact that nematodes were more abundant during the fall, winter and spring months than during the summer months challenges investigation; resistance by nematodes to extremes in environment has been pointed out in numerous cases (Hoepli, 1926).

SUMMARY

1. In a limnological survey of the Hocking River fifty-two genera of zoöplankton were found. The plankton consisted of sixteen genera of Protozoa, seventeen genera of Annelida, and eleven genera of Arthropoda.

2. A combination of retarded rate of flow, higher temperature, and senescence of the water at a given point along the river tend to increase plankton productivity. Domestic pollution probably hastens senescence and increases abundance. Inorganic wastes tend to decrease abundance of organisms.

3. Stability of hydrographic conditions and high temperature, except in the case of nematodes, are important factors in determining the monthly and seasonal distribution.

4. There is some evidence that degree of pollution determines the quality as well as the quantity of plankton along the Hocking River.

BIBLIOGRAPHY

- Allen, W. E. 1920. A Quantitative and Statistical Study of the Plankton of the San Joaquin River and Its Tributaries in and near Stockton, California, in 1913. Univ. Calif. Pub., Zool., 22: 1-292.
- Biological Survey of the Genesee River System. Suppl. to the 16th Ann. Rept., State of N. Y. Conser. Comm., 1927, 100 pp.
- Biological Survey of the Oswego River System. Suppl. to the 17th Ann. Rept., State of N. Y. Conser. Comm., 1928, 248 pp.
- Biological Survey of the Erie-Niagara System. Suppl. to 18th Ann. Rept., State of N. Y. Conser. Comm., 1929, 244 pp.
- Eddy, S. 1932. The Plankton of the Sangamon River in the Summer of 1929. State of Ill. Div. Nat. Hist. Surv., 19: 469-486.
- Forbes, S. A., and R. E. Richardson. 1913. Studies on the Biology of the Upper Illinois River. Bull. of Ill. State Lab. of Nat. Hist., Vol. IX.
1919. Some Recent Changes in Illinois River Biology. Bull. of Ill. State Lab. of Nat. Hist., Vol. XIII.
- Galtsoff, P. S. 1924. Limnological Observations in the Upper Mississippi, 1921. Bull. U. S. Bur. Fish., 39: 347-438.
- Hoepli, R. J. C. 1926. Studies of Free-Living Nematodes from the Thermal Waters of Yellowstone Park. Trans. Am. Micr. Soc., 45: 234-255.
- Kofoid, C. A. 1903. The Plankton of the Illinois River, 1894-1899, with Introductory Notes upon the Hydrography of the Illinois River and Its Basin. Part I. Quantitative Investigations and General Results. Bull. Ill. State Lab. Nat. Hist., 6: 95-629.
1908. The Plankton of the Illinois River, 1894-1899, with Introductory Notes upon the Hydrography of the Illinois River and Its Basin. Part II. Constituent Organisms and Their Seasonal Distribution. Bull. Ill. State Lab. Nat. Hist., 8: 1-354.
- Lackey, J. B. 1938. A Study of Some Ecological Factors Affecting the Distribution of Plankton. Ecol. Monogr., 8: 502-527.
- Reinhard, E. G. 1931. The Plankton Ecology of the Upper Mississippi, Minneapolis to Winona. Ecol. Monogr., 1: 395-464.
- Roach, L. S. 1931. An Ecological Study of the Plankton of the Hocking River. Original Thesis for Master's Degree at Ohio University.
1932. An Ecological Study of the Plankton of the Hocking River. Bull. Ohio Biol. Surv., 5: 253-279.
- Shelford, V. E., and S. Eddy. 1929. Methods for the Study of Stream Communities. Ecology, 10: 382-391.
- Ward, H. B., and G. C. Whipple. 1918. Fresh Water Biology. John Wiley & Son, Inc., New York, N. Y.
- Welch, P. S. 1935. Limnology. McGraw-Hill Book Co., Inc., New York, N. Y.
- Wiebe, A. H. 1927. Biological Survey of the Upper Mississippi River with Special Reference to Pollution. Bull. U. S. Bur. Fish., 43: 137-167.

Survival

The author is a geologist who graduated from Harvard with an A.B., *magnum cum laude*, and later took a Ph.D. at Chicago University with the same label of excellence. He is a top flight writer who has furnished articles for such reviews of distinction as *The Yale Review*, *The American Mercury*, *The Forum*, *The American Scholar* and *Harper's Magazine*.

The volume is an excellent popular review from an evolutionary point of view of life in terms of the latest biological thought. Apparently the work is not intended for the scientific student, as it is neither indexed nor does it have a bibliography or a detailed table of contents. To the scientist reader it is even annoying at times because the author frequently uses brilliant suggestive or explanatory ideas which apparently are not always original, but which cannot be traced back to an earlier writer for a fuller explanation.

The popular form of the exposition is such through a rich and brilliant use of figures of speech and a sufficient inweaving of the emotional to keep the reader awake and even on his toes for fear he will miss some of the more thrilling incidents in this panorama of life. From the view of cold logic the author has overwritten his subject.

The contents run as follows:

"The Question and the Quest." After pointing out the conflict in biological philosophy between mechanism and vitalism the author suggests, "The student of earth history sees in retrospect what could never have been foretold. Life was a new experiment under the sun. A bit of jelly quivering to the surge of the sea might scarcely have been suspected of power to alter the earth. . . . If there is any meaning . . . in the restless drive of life, a billion years of living should contain it. To search those years for that meaning will be the object of this book."

Chapter I. "In the Beginning:" a discussion of Pre-Cambrian conditions. Chapter II. "The Other Side of Progress:" sedentary life. III. "The Mechanics of Success:" evolution and locomotion. IV. "The House Divided:" biological conflicts, plant life, herbivores, carnivores, food chains, over-population. "The house of life divided against itself stands only because it is divided." V. "Life Without Struggle:" the degeneracy of parasitism, with an interesting review of human social parasites. VI. "The Way of Love:" bisexual reproduction, maternal care, family life, co-operation. VII. "The Broader Brotherhoods of Flesh:" life at unicellular level, at coelenterate and colonial level at the level of herd life and at social levels. VIII. "The Tragic Rhythm:" death in too high specialization, other evolutionary trends, life only possible hand in hand with death and extinction. IX. "The Business of Growing Up:" various evolutionary "improvements" and their values. X. "Is Man an Absurdity? When Nature evolved modern man, she improved only the brain, the larynx and the hands and allowed all other essential gadgets to degenerate. . . . Man is an appalling hodge-podge of second-hand odds and ends," but "the gravest dangers for man as a species lie less in the crumbling beast than in the bungling god." XI. "The Embarrassment of Being Different. . . . No other creature has faced sterner problems with fewer guides to workable solutions, but solutions may come through man's unique feature of discontent with discontent. . . . Self-directed evolution so far as he knows, is an adventure without precedent in a billion years."

The exposition is full of minor errors of fact, many of which could have been caught by competent readers. We quote, p. 152, "Drone bees are so specialized as gigolos that they are incapable of any other pursuit. They are unable to gather pollen (*should be* nectar) because their tongues are too short. They are unable to work on the hive because they have no wax glands (*Should be* because of their nervous mechanism). They are unable to fight because they have no stings (*again* because of the nervous control of behavior). They would rather starve than collect food for themselves" (*anthropomorphic expression*). This careless writing disregards all previous careful observations and precise experimentation by scientists in general.

The volume is so full of highly suggestive ideas (though too frequently based on highly selected evidence) that we recommend it in spite of its numerous minor slips. It is interesting and actually absorbing page after page.—C. H. Kennedy.

Patterns of Survival, by John Hogden Bradley. 223 pp. New York, The Macmillan Co., 1938. \$2.25.

THE EFFECTS OF MAN-MADE MODIFICATIONS ON
THE FISH FAUNA IN LOST AND GORDON
CREEKS, OHIO, BETWEEN 1887-1938

MILTON B. TRAUTMAN
Franz Theodore Stone Laboratory,
Ohio State University,
Put-in-Bay, Ohio

If the fundamental principals regulating the present numerical abundance of a species are to be understood, it is necessary to obtain some understanding of the numerical fluctuations of that species over a comparatively long period of time and to learn the reasons for such fluctuations. Research to determine these facts is not very difficult with such conspicuous animals as the black bear, white-tailed deer, passenger pigeon, or bob-white. It is more difficult with fishes, principally because of the inability of early observers to identify correctly these usually inconspicuous animals. As a consequence, there are few dependable observations in Ohio on fishes during early historic time. One of the finest series of observations available is from the Lost and Gordon creek systems of the Maumee drainage, in Defiance and Paulding counties of western Ohio.

This portion of the Maumee Valley was first invaded by small numbers of white men early in the eighteenth century. Fort Defiance, Defiance County, was built in 1794, and this site, where the city of Defiance now stands, has since been continuously occupied by the white man. Before 1794 Indians had a settlement there, which extended along the Maumee River for a considerable distance (Howe, 1902: 541-542). Adjacent to the village there was said to have been "highly cultivated" land "with one thousand acres of corn besides immense apple and peach orchards."

Despite early occupancy about the present site of the city of Defiance, the counties of Defiance and Paulding were not heavily settled, nor was much land cultivated, until after 1850. These counties lay principally in the Black Swamp, and the topography of this swamp prohibited ready drainage. Extensive ditching was not begun until after 1850. Even as late as 1874 (Winchell, 1874a: 438) almost two-thirds of Defiance County still contained heavy forests. In Paulding County "about eighty-nine per cent of the acreage was classified as

uncultivated" and deer, black bears and wolves were still sufficiently numerous to attract hunting parties from as far distant as southern Ohio (Winchell, 1874b: 335-336).

The first published ichthyological explorations of Defiance County began in 1887, during the early period of swamp drainage and forest removal. In July of that year Meek¹ made his investigations of the Lost and Gordon creek systems. In 1889 Meek (1889: 435-440) published a list of the fishes captured, indicated their abundance, and gave a short, accurate description of the streams and adjacent country.

Meek stated that he seined in the following localities, spending less than a day in each: Gordon Creek about one mile above its mouth; the same creek about ten or twelve miles upstream near Cicero;² and Lost Creek about two and a half miles southwest of Farmer. He described Gordon Creek as small, containing little or no flowing water in summer, and with the pools becoming nearly dry at that season. When he seined the stream near its mouth in 1887 it had ceased to flow and collecting was done in a few *deep holes*. The creek near Cicero was little more than a small brook with a muddy bottom and occasional stretches of sand. Meek stated that Lost Creek was larger than Gordon, and that it had a more sandy bottom; that it was fed by springs in the headwaters, and was seldom, if ever without running water. A few miles below Farmer, Lost Creek lost itself in a large marshy tract of land that was covered with a dense growth of underbrush.³

Meek mentioned that formerly the greater portion of Defiance County was heavily timbered, and that within the past thirty years much land had been cleared. He also stated that although large woodland remnants remained, most of them had been depleted of their best timber, and the remaining trees had been more or less injured by fire. Meek's description of the country agrees with those of other competent writers of that period and region.

A rather detailed survey of the Maumee river system was made in the summer of 1893 by Philip H. Kirsch. His report

¹Seth E. Meek, one of America's outstanding ichthyologists, was born in 1859 at Hicksville, Defiance County, Ohio. His investigations were conducted in Farmer, Mark and Hicksville townships, Defiance County.

²This former village is not usually shown on recent maps. It was located in northeast Hicksville Township, Defiance County. See U. S. Geol. Surv. map, Bryan Quadrangle, Ohio; 1914.

³Seemingly that portion of Mark Township that is enclosed in a dotted line on Winchell's map (1874a: opp. p. 422).

(1895: 315-337) gives us an accurate conception of the numerical status of many fish species throughout the Maumee system, which materially assists in our understanding of the population fluctuations and physical modifications that have occurred in the creeks under discussion. Kirch included Meek's data in his report but did not personally investigate Lost or Gordon creeks.

Dr. Raymond C. Osburn and Mr. Edward L. Wickliff began in 1920 a state-wide survey of fishes for the Ohio Division of Conservation, which included collecting in the Maumee drainage. I began to assist in this survey in 1925 and since have made many collections in the Maumee system. I first collected in Lost and Gordon creeks in 1930, and was then assisted by Mr. Robert B. Foster.

On May 22 and 30, 1938, Mr. George A. Moore⁴ and I began the investigations of Lost and Gordon creeks which have made this comparative study possible. We collected fishes in every locality seined by Meek, and in eight others as well. The major physiographic features of both stream systems were observed, as were the major floral types. It was apparent that vast modifications had occurred in the streams and watersheds since 1887. All except small sections of the streams had been dredged or straightened. Dredging to a depth of fifteen and twenty feet had completely drained that section of Lost Creek where the stream had formerly "lost itself in a large marshy tract of land (Meek, 1889: 435)." In several localities dredging had penetrated into a hard pan of grayish-blue clay. The most recently dredged sections contained no pools or well-defined riffles, the depth of water was uniformly shallow and the bottom cover was almost or entirely absent. Wherever hard-pan occurred it was swept clean except for occasional, small accumulations of sand and small-sized gravel. Rooted aquatic vegetation was absent. Wherever the dredging had occurred five or more years previously, bank cutting, and occasional lodged stumps and timber had begun to cause the formation of pools and sand bars. The straightening and dredging of the former, meandering creeks caused the formation of ox-bows. Some of the ox-bows were only a few yards, others were almost a mile in length. Many were connected with a dredged ditch except in periods of low water. Some contained a series of interrupted pools. None had flowing water. All possessed a profusion of

⁴I wish to acknowledge indebtedness to Mr. Moore, of the Oklahoma Agricultural and Mechanical College, for his assistance in the collection of field data.

algae, and some contained much submerged and emergent rooted aquatic vegetation.

The undredged portions of both stream systems were in the headwaters. These sections were characterized by well-defined pools of as great as seven feet in depth, in which was usually an abundance of timber, boulders, gravel, rooted aquatic vegetation and other cover for fishes. The riffles were likewise well-defined and contained much cover in the form of boulders, gravel and vegetation. It is assumed that conditions in these undredged sections, and particularly where they flowed through woodlands, were comparable to conditions in 1887.

Because of topographical features the headwaters of Lost Creek, and to a lesser extent of Gordon Creek, are very different from the lower courses. Many of the tributaries of Lost Creek and a few of those of Gordon Creek began at about 825 feet above sea level, and in the first one or two miles of their course drop to 750 feet.⁵ At about the 750 foot level the streams enter the former Black Swamp, and in the remaining 3 to 15 miles descend only about 50 feet. Most of the headwater tributaries flow at right angles through a series of ridges, of which two are outstanding. These lie parallel to each other, and cross Hicksville and Farmer townships, Defiance County, in a northeast-southwest direction. The upper one has been called the lower margin of the St. Mary's Ridge, and the other the Van Wert Ridge (Winchell, 1874a: 430, and map opp. p. 422). Springs and artesian wells are numerous on these uplands and particularly about the headwaters of Lost Creek. The soil on the uplands is of moderate fertility, is readily eroded, and often contains much gravel, sand and many boulders. Occasional sand blow-outs occur. The flora of the most sandy portions is of an oak-opening type. The former forests have been reduced to remnant woodlands and woodlots, and are usually grazed. The meadows are often heavily grazed, and all except an occasional fence row or stream bank is under some form of cultivation.

The lower courses of the streams, which formerly meandered across the Black Swamp, now traverse a level, well-drained plain whose usually dark, sandy-loam soil is in general very fertile. The remnant woodlands, of swamp-forest type, are few and are generally grazed. The remaining portion of the plain is under intensive cultivation except for an occasional fence row

⁵See U. S. Geol. Surv. map. Bryan Quadrangle, Ohio; 1914.

or stream bank. The loamy soil erodes rapidly along the stream banks and wherever there is sufficient slope.

Meek's report indicates that he found collecting conditions favorable in 1887, and that a fairly representative sample of the fish fauna was obtained. Collecting in 1938 was conducted under extremely favorable conditions, and all habitat types were given equal attention. Table I compares the results of these two investigations.⁶

It will be observed that Meek recorded 22 species from Lost Creek, 21 species from Gordon Creek, and had a total of 26 species from both. I collected 30 species in Lost Creek, 26 in Gordon Creek, and had a total of 33 species for both. Together Meek and I obtained a total of 41 species for the two systems.

Meek recorded 7 species which I failed to obtain. Of these *Dorosoma cepedianum*, *Moxostoma duquesnii*, *Notropis volucellus*, *Esox vermiculatus*, and *Lepomis megalotis* probably still occur in the two systems and further collecting might reveal them. Since all five are essentially pool or bayou inhabitants I assume that recent dredging has decreased the amount of their habitat and greatly disturbed much of that remaining. Consequently their numbers have decreased. The fish recorded by Meek as *Chrosomus erythrogaster*, if that species, occurred as a relict in the clear, spring streams of the uplands. If the species was the bog-inhabiting *Chrosomus eos*, then it inhabited the Black Swamp proper. The former species seems the most logical.⁷ I was unable to find the lowland-inhabiting *Aphredoderus sayanus*, a species recorded only in one other locality in Ohio. It has probably become extirpated with the draining of the Black Swamp.

I collected 15 species which Meek failed to obtain. Of these *Carpiodes cyprinus*, *Minytrema melanops*, *Notemigonus crysoleucas*, *Schilbeodes gyrinus*, *Fundulus notatus*, and *Cottus bairdii* were assumed to have been present in 1887. *Hypentelium nigricans* and *Notropis deliciosus* may have been present but probably have become more numerous recently with the

⁶Since Meek employed comparative terms I have done likewise. In most instances these terms are adequate for the present purpose.

⁷I have corresponded with Dr. Alexander Wetmore of the National Museum, Mr. Alfred C. Weed of the Field Museum, and Mr. H. Walton Clark of the California Academy of Science concerning the existence of specimens collected by Meek in Lost and Gordon Creeks. None are present in any of these institutions. In a letter of January 24, 1939, Dr. Wetmore informed me that, although Meek obtained U. S. Nat. Mus. catalogue numbers for his specimens, the fish were probably never forwarded to that Museum. Because of failure to find Meek's material I have been unable to recheck his identifications.

increase in amount of sandy riffles and pools. *Moxostoma erythrurum* and *Moxostoma rubreques* were probably present, and if so were recorded, in part at least, as *Moxostoma duquesnii*. *Cyprinus carpio* was probably not present in Lost and Gordon Creeks in 1887, since the first introductions in the Maumee system had taken place only a few years before (Cole, 1905: 547). *Phenacobius mirabilis*, a species readily identified, was not recorded in the Maumee drainage until 1920 (Osburn, Wickliff and Trautman, 1930: 173). Since then this inhabitant of roily, prairie-like streams has numerically increased so rapidly that it is now one of the dominant species throughout the Maumee drainage. I assume that the bullheads recorded by Meek as *Ameiurus nebulosus* were *Ameiurus natalis*. *A. nebulosus* is seldom found in small streams in Ohio and is numerous only in ponds, lakes or large rivers. *A. natalis* is abundant in small streams similar to the undredged portions of Lost and Gordon Creeks, and in these streams I found them in good numbers. *Etheostoma blennioides* was probably present but may have invaded the two systems since the draining of the Black Swamp. *Pomoxis annularis* should have been present in 1887. Its numbers may have recently increased because the species thrives in roily water, and has been stocked repeatedly in the two systems in recent years.

The most interesting facts are obtained from a comparison of the numerical status of species collected by both Meek and me, and from a study of conditions in which these fish were found. Table I and additional data indicates:

The collections from *undredged* sections show that, with few exceptions, there has been little change in numerical abundance of the various fish species in these sections between 1887 and 1938.

The collections from *dredged* sections indicate that, with few exceptions, there has been a drastic change in numerical abundance of the various fish species in these sections between 1887 and 1938.

The food fishes, including the sucker *Catostomus commersonnii*, suckers of the genus *Moxostoma*, bullheads of the genus *Ameiurus*, and all sunfish species except possibly *Pomoxis annularis*, were notably less numerous in 1938 than in 1887. Their numerical decrease was apparently the result of dredging, which has destroyed much of their habitat.

The forage fishes that displayed the greatest decrease in numbers were those requiring clear water, a constant flow, well-defined pools, or aquatic vegetation. Included in this group were such species as *Nocomis biguttatus* and *Rhinichthys atratulus*. These were numerous only in undredged sections.

The forage fishes that displayed the greatest numerical increase are all tolerant of dredged conditions with its resultant increase in turbidity of water and accumulation of clean-swept sand, rapid fluctuations in height of flow and speed of current, and lack of rooted aquatic vegetation and other cover. *Ericymba buccata*, the recent invader *Phenacobius mirabilis*, and *Pimephales promelas*, are excellent examples.

Although food fishes have decreased numerically, no obvious change in total numbers of forage fishes is apparent. Seemingly the increase in numbers of those forage species tolerant to dredged conditions tends to balance the numerical decrease of those not tolerant to dredging. Therefore from a cropping standpoint the streams today are essentially bait producers.

Ichthyological investigations of the past and present show that some species, which are rather generally distributed elsewhere in Ohio in similar habitats, are conspicuously absent in Lost and Gordon Creeks. The clear, undredged headwaters seem particularly suited to the big-eyed chub *Hybopsis amblops amblops* (Rafinesque); the rosy shiner *Notropis rubellus* (Agassiz); the rainbow darter *Poecilichthys coeruleus* (Storer); and the fan-tailed darter *Catnotus flabellaris flabellaris* (Rafinesque). Since Kirsch (1895), E. L. Wickliff, myself and others have found these species very rare or absent in the Black Swamp section of the Maumee drainage, may it not be that they have been unable to penetrate the lowland streams and thus reach the upland tributaries with their apparently suitable habitats?

Investigations also indicate that such species as the silver mullet *Moxostoma anisurum* (Rafinesque); the yellow stone catfish *Noturus flavus* Rafinesque; the brindled madtom *Schilbeodes miurus* (Jordan); the mud pickerel *Esox vermiculatus* Le Sueur; and the northern sand darter *Ammocrypta pellucida pellucida* (Baird), were more numerous in the Maumee drainage in 1893 (Kirsch, 1895) than subsequently. It is suggested that possibly their apparent numerical decrease was the result of a reduction in the amount of habitat suitable for them.

The collecting in the Lost and Gordon systems has not produced one small-mouthed bass *Micropterus dolomieu dolo-*

mieu Lacépède or a large-mouthed bass *Huro salmoides* (Lacépède), and this despite repeated plantings during recent years. Both species have been in the Maumee River adjacent to Gordon Creek since 1887 (Meek, 1889: 439), and therefore could have readily invaded that stream. Anyone acquainted with the ecological conditions under which the two bass species live in Ohio streams can readily understand why these species are not numerous in Lost and Gordon Creeks. This is particularly true of dredged sections.

In conclusion I wish to point out that in Ohio the absence of game species and the recent decrease of pan and food fishes is not confined to the Lost and Gordon systems. Man-made modifications, such as are now present in these systems, are also present in much of Ohio's waters. One needs only to study the past and present numerical status of Ohio fishes to realize the truth of this statement.

LITERATURE CITED

- Cole, Leon. J. 1905. The German carp in the United States. Report of U. S. Bur. of Fish. (1904); 523-641, Pls. 1-3.
- Howe, Henry. 1902. Historical collections of Ohio. C. J. Krehbiel and Co., Cincinnati, 1: 1-922.
- Kirsch, Philip H. 1895. A report upon investigations in the Maumee River basin during the summer of 1893. Bull. U. S. Fish Comm., 14: (1894). 315-337.
- Meek, Seth E. 1889. Notes on a collection of fishes from the Maumee valley, Ohio. Proc. U. S. Nat. Mus., 11: (1888). 435-440.
- Osburn, Raymond C., Edward L. Wickliff and Milton B. Trautman. 1930. A revised list of the fishes of Ohio. Ohio Journ. Sci., 30: (3), 169-176.
- Winchell, N. H. 1874a. The geology of Defiance County. Rept. of Geol. Surv. of Ohio. 2: Pt. 1, 422-438, 1 map.
- 1874b. Report on the geology of Paulding County. Rept. of Geol. Surv. of Ohio. 2: Pt. 1, 335-351, 1 map.

TABLE I. RELATIVE ABUNDANCE OF VARIOUS FISH SPECIES AS RECORDED IN 1887 AND 1938

SPECIES	1887 (Meek)			1938 (Trautman)				REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		GORDON CREEK		
				Dredged	Undredged	Dredged	Undredged	
<i>Dorosoma cepedianum</i> (Le Sueur) Gizzard Shad		Rather abundant near mouth						Probably occurs at present near mouth of Gordon Creek
<i>Carpiodes cyprinus</i> (Le Sueur) Quillback			one adult			A few young in 1930		Young are numerous in some dredged streams of Paulding and Defiance counties
<i>Catostomus commersonii</i> (Lacepede) Common White Sucker	Abundant	Abundant	Uncommon or common	Very common or abundant	Uncommon or common	Uncommon or abundant	Very common or abundant	More numerous in undredged localities; recorded from every undredged locality
<i>Hypentelium nigricans</i> (Le Sueur) Hog Mollie			Usually uncommon; sometimes common where there is considerable sand and gravel	Usually common or abundant on sand and gravel riffles				Increase in amount of sand and gravel probably caused increase in fish numbers
<i>Erimyzon oblongus claviformis</i> (Girard) Western Creek Sucker	Scarce	Scarce	Scarce	More numerous than in dredged portions	Scarce	Scarce	Scarce	As elsewhere in western Ohio, this prairie-stream species may migrate up these creeks in large numbers in early spring to spawn.
<i>Moxostoma melanops</i> (Rafinesque) Spotted Sucker				1 subadult				Usually occurs in numbers in deep pools of fair-sized streams and not in small creeks such as these
<i>Moxostoma valenciennesi</i> (Le Sueur) Black Mullet	Abundant	Abundant	Meek's <i>M. valenciennesi</i> was presumably a composite of this and the two following					If this species of deep clear water occurs at present, it must be very rare

Table I—(Continued)

SPECIES	1887 (Meek)			1938 (Trautman)				REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS	LOST CREEK		GORDON CREEK		
				Dredged	Undredged	Dredged	Undredged	
<i>Moxostoma erythrum</i> (Refinesque) Golden Mullet			Presumably the most numerous <i>Moxostoma</i> in 1887				Young numerous in 1930	Since this sucker is chiefly an inhabitant of gravelly riffles and deep pools of clear streams, it may have been more numerous in 1887 than at present
<i>Moxostoma rubreques</i> Hubbs Greater Redhorse			Probably present but confused with <i>M. duquesnei</i>		1 specimen		1 specimen	Like the preceding, this species is numerous in the Maumee River at the mouth of Gordon Creek
<i>Cyprinus carpio</i> Linnaeus Carp			First introduced into Great Lakes waters of Ohio in 1879 (Cole, 1906; 547); probably very local in distribution in 1887		1 small young		A few young taken in a deep pool	
<i>Nocomis biguttatus</i> (Kirtland) Horny-headed Chub	Abundant	Abundant	Recorded as <i>Hypopsis kentuckiensis</i> ; may have included some <i>Nocomis micropogon</i> (Cope)		Abundant			Abundant in undredged portions of Lost Creek where there was some rooted aquatic vegetation
<i>Rhinichthys atratulus</i> <i>meleagris</i> Agassiz Western Black-nosed Dace	Not abundant		Recorded as <i>Rhinichthys atronatus</i>		Abundant in spring-fed headwaters that flow from a large moraine			Apparently a relict which has remained in the spring-fed headwaters
<i>Semotilus atromaculatus</i> <i>atromaculatus</i> (Mitchill) Northern Creek Chub	Abundant	Abundant		Common	Abundant	Uncommon	Common	Most numerous in small undredged waters having well-defined riffles and pools

<i>Notropis volucellus volucellus</i> (Cope) Northern Mimic Shiner	Not very abundant	Recorded as <i>Notropis volucella</i> . Meek was one of the first ichthyologists to separate this species from <i>Notropis ditiosus</i> .	Common in sandy portions downstream; not in small headwaters	Uncommon; present only near mouth and over a sandy bottom	Probably still occurs sparingly in the deeper pools. Numerous in Maumee River near mouth of Lost Creek.
<i>Notropis ditiosus stramineus</i> (Cope) Northern Sand Shiner		Recorded by Meek in Maumee River. From Meek's writings (1889: 436-437) it is apparent that he could correctly identify this species	Very common or abundant	A few	Probably has increased greatly in numbers since 1887 because of increase in amount of sand and suitable habitat
<i>Notropis spilopterus</i> (Cope) Northern Steel-colored Shiner	Not abundant	Recorded as <i>Notropis whipplei</i>	Abundant	A few	Not numerous in headwaters; a species tolerant of roily water.
<i>Notropis cornutus</i> (Mitchill) Common Shiner	Very abundant	Recorded as <i>Notropis megalops</i> (Rafinesque)	Abundant	Common	Headwaters apparently contain typical <i>N. cornutus frontalis</i> (Agassiz). Downstream portions contain varying percentages of <i>frontalis</i> and intergrades between <i>frontalis</i> and <i>chrysocephalus</i> (Rafinesque)
<i>Notropis umbratilis cyanocephalus</i> (Copeland) Northern Red-finned Shiner	Scarce	Recorded as <i>Notropis lyliurus</i> Jordan and Gilbert		Scarce or uncommon	A pool species not tolerant to recent dredging
<i>Ericymba buccata</i> Cope Silver-jawed Minnow	Much less abundant than in Lost Creek		Abundant, especially over a sandy bottom	Usually absent or scarce; abundant only over sandy bottom	Dredging with resultant increase of sand apparently resulted in increased numbers of fish
<i>Phenacobius mirabilis</i> (Girard) Sucker-mouthed Minnow	Very abundant	Not recorded by Kirsch (1895)	Uncommon, common or abundant	Rare or uncommon	Apparently a recent invader and one tolerant to turbid water

Table I—(Continued)

SPECIES	1887 (Meek)		REMARKS	1938 (Trautman)				REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)		LOST CREEK		GORDON CREEK		
				Dredged	Undredged	Dredged	Undredged	
<i>Notemigonus crysoleucas auratus</i> Rafinesque Golden Shiner			Recorded as <i>Notemigonus chrysocentrus</i>		Rare, only in weedy pools		Rare, only in ox-bows or weedy pools	
<i>Chrosomus erythrogaster</i> Rafinesque Southern Red-bellied Dace	Scarce		May have been <i>C. eos</i> instead of <i>C. erythrogaster</i> . See p. 279 and footnote No. 7					A relict in this section of Ohio; may now be extirpated
<i>Hyborthynchus notatus</i> (Rafinesque) Blunt-nosed Minnow	More abundant than <i>Pimephales p. promelas</i>	More abundant than <i>Pimephales p. promelas</i>	Recorded as <i>Pimephales notatus</i>	Generally distributed, usually uncommon, only abundant in one locality	Generally distributed, usually common	Generally distributed, usually uncommon	Generally distributed, usually common	Averaging less numerous than <i>Pimephales p. promelas</i> and markedly so in dredged portions
<i>Pimephales promelas promelas</i> Rafinesque Northern Fat-headed Minnow	Not abundant	Not abundant	Its scarcity as indicated by Kirsch (1893: 398) suggests that this essentially prairie-stream fish was less common in the Ohio section of the Maumee drainage before 1900 than after 1830 (Trautman: records unpublished)	Common or abundant in all sections except those most devoid of cover	Common or abundant	Common or abundant	Common or abundant	This inhabitant of prairie-like and rocky streams has probably increased greatly throughout northwestern Ohio in recent years
<i>Camptostoma anomalum patulum</i> (Agassiz) Mississippi Yellow-mouthed Minnow		Not very abundant	Recorded as <i>Camptostoma anomalum</i> (Rafinesque)	A few	Uncommon, common or abundant; found at all stations		1 specimen	

<i>Ameiurus melas melas</i> (Rafinesque) Northern Black Bullhead	Abundant	Abundant	Recorded as <i>Ameiurus melas</i>		Uncommon, common or abundant	1 specimen	Uncommon or common	Habitat destroyed by dredging
<i>Ameiurus nebulosus</i> (Le Sueur) Northern Brown Bullhead	Very abundant	Very abundant	Recorded as <i>Ameiurus nebulosus</i> ; almost unquestionably misidentified; must have been <i>Ameiurus natalis</i> since <i>nebulosus</i> is a deep-water inhabitant					
<i>Ameiurus natalis natalis</i> (Le Sueur) Northern Yellow Bullhead					Usually common or abundant in pools and especially those contain- ing aquatic vegetation	2 specimens, 1 found hiding under old shoe, other under brick	Usually common in pools, abundant in ox-bows	Habitat destroyed by dredging
<i>Schilbroodes eryinus</i> (Mitchill) Tadpole Madtom					1 in weedy pool		2 in weedy ox-bow	
<i>Umbra limi</i> (Kirtland) Western Mudminnow	Rather common in small bayous	Rather common in small bayous			Still fairly common in undisturbed weedy head- water pools			Habitat destroyed by dredging
<i>Esox vermiculatus</i> Le Sueur Mud Pickerel	Not very abundant	Not very abundant	Recorded as <i>Lucius</i> <i>vermiculatus</i>					This inhabitant of weedy bayous may still be present in small numbers in un- dredged portions
<i>Fundulus notatus notatus</i> (Rafinesque) Black-striped Topminnow						2 specimens in 1 collection	Common in undredged ox-bow	
<i>Aphredoderus sayanus</i> (Gilliams) Pirate-Perch		One small specimen taken	Supposed to have been given to U.S. National Museum; catalogued as No. 40104; see footnote No. 7					This relict species has probably been extirpated because of destruction of its habitat
<i>Hadropterus maculatus</i> (Girard) Black-sided Darter	Not abundant	Not abundant	Recorded as <i>Etheostoma aspro</i> (Cope and Jordan)		A few		A few	Inhabitant of the larger- undredged pools that con- tain a moderate flow of water

Table I—(Continued)

SPECIES	1887 (Meek)			REMARKS	LOST CREEK		GORDON CREEK		REMARKS
	LOST CREEK (Undredged)	GORDON CREEK (Undredged)	REMARKS		Dredged	Undredged	Dredged	Undredged	
<i>Boleosoma nigrum nigrum</i> (Rafinesque) Western Johnny Darter	Abundant	Abundant	Recorded as <i>Etheostoma nigrum</i> Rafinesque	Uncommon generally; rare in recently dredged portions	Common or abundant in gravelly riffles and pools	A few	Common where there is gravel	A marked paucity only in most recently dredged portions	
<i>Poecilichthys spectabilis</i> Agassiz Orange-throated Darter	One specimen?		The <i>Etheostoma coeruleum</i> Storer of Meek was either <i>P. coeruleus</i> or <i>P. spectabilis</i>	Uncommon	Common or abundant in undisturbed portions			A prairie-stream species; may have invaded Lost Creek with the draining of Black Swamp	
<i>Etheostoma blennioides blennioides</i> Rafinesque Northern Green-sided Darter					Rare or uncommon, usually frequenting the faster, larger riffles		Rare	Probably a recent invader	
<i>Lepomis cynellus</i> Rafinesque Green Sunfish	Abundant	Abundant		A few	Usually common; sometimes abundant	A few	Usually common, abundant, in ox-bows	Most numerous in well-defined pools and ox-bows	
<i>Lepomis megalotis</i> (Rafinesque) Long-eared Sunfish	Less abundant than <i>Lepomis cynellus</i>		Meek probably had <i>L. m. pelastus</i> (Cope) the form most numerous in the Maumee drainage					Recent collecting indicates that this species is less widespread and less numerous in Ohio section of Maumee drainage than it was in 1893 (Kirsch, 1895: 331)	
<i>Pomoxis annularis</i> (Rafinesque) White Crappie					Sixteen specimens, all from deep holes		A few	Both creeks have been repeatedly stocked with this species	
<i>Cottus bairdii bairdii</i> Girard Northern Muddler				Rare, usually absent	Abundant in the small streams containing many springs; uncommon in Lost Creek proper			A relict in clear, small brooks; has been recorded only once before in Ohio section of the Maumee drainage (Kirsch, 1895: 332)	

BOOK NOTICES

Weather

The publishers are to be congratulated on the attractiveness of "Weather"—the first of a forthcoming series of popular treatments on natural phenomena by Gayle Pickwell. The story of weather is vividly told in large pictures, supplemented by fascinating writing devoid of scientific terms and formulae. The book is for the layman and is not intended as a textbook for use in a technical course, although it should serve nicely as a supplement in Geography, Meteorology, and Climatology courses. Especially fine are the picture clouds, lightning, dew and frost. The author's enthusiasm for fine pictures has resulted, however, in the inclusion of some subjects remote from the theme of the book. Engraving, printing, and binding are superb.—*Paris B. Stockdale.*

Weather, by Gayle Pickwell. x+170 pp. New York, McGraw-Hill Book Company, Inc., 1938. \$3.00.

Heredity for You and You and You

This book is the first attempt at a popular presentation of human inheritance since Popenoe's "The Child's Heredity," published in 1929. The author is a layman in the field of genetics, but is a writer of considerable experience. He is gifted indeed in his ability to present technical material in an absorbing manner, for his book is a gem of writing. He has been assisted throughout by a geneticist, Dr. Morton D. Schweitzer, of Cornell Medical College, so that the book is accurate in most of its details. A delightful series of cleverly drawn diagrams presents the salient facts in striking form. The diagrams tend somewhat towards oversimplification; this is rectified to a certain extent by the accompanying text. It is to be regretted that a book so well done in other respects should contain so many teleological statements. The author's interest and enthusiasm completely capture the reader, and the book will be read as eagerly as any novel. It is highly recommended to those who desire an introductory acquaintance with their own inheritance and that of their fellow men.—*L. H. S.*

You and Heredity, by Amram Scheinfeld. xvii+434 pp. New York, Frederick A. Stokes Co., 1939. \$3.75.

Plant Genetics

The new second edition of Sansome and Philp is, in the opinion of the reviewer, the best reference available for teachers of advanced plant genetics. Chapter I contains a review of mitosis and meiosis, and of the various simple types of Mendelian inheritance. Chapter II deals with linkage and the most recent interpretations of chiasmata and crossing over. Chapter III takes up the various theories regarding the constitution of the gene and recent findings relative to position effects. Chapter IV, on Variegation and Chimeras, appears for the first time in the Second Edition. Chapters V, VI and VII are devoted to polyploids, and Chapter VIII is entitled Euploids and Aneuploids. Chapter IX discusses various kinds of chromosomal aberrations under the heading of structural hybridity. Chapter X deals with interspecific hybridization, discussing numerous examples. Chapter XI discusses plant genetics in relation to taxonomy and evolution. An excellent bibliography of the literature on plant genetics is included.

The book is perhaps too technical for a text, even for advanced students of plant genetics. We heartily recommend it, however, for the purpose for which it was primarily intended, a reference for the teacher and the research worker in plant genetics.—*D. C. Rife.*

Recent Advances in Plant Genetics (Second Edition), by F. W. Sansome and J. Philp. xi+347 pp. Philadelphia, P. Blakiston's Sons & Co., 1939.

Light

The seventh edition of an intermediate text book on light by R. A. Houston will undoubtedly receive the acclaim of many teachers in physics. The new edition has brought the already well established text up to the present time and it contains many new colored plates and much new material.

Part I is substantially unchanged, but Part II contains some rearrangement of material and three new colored plates. In Part III the ultraviolet and infrared spectra are discussed together, the material on the theory of spectra is rewritten and enlarged upon. The Chapter XVII is now devoted to X-rays and photo-electricity. It has to a large degree been rewritten and it contains additional illustrations and plates. A chapter on quantum theory has been inserted and now Chapter XIX contains much new material which was a portion of Chapter XX in earlier editions. In Part IV there are added to the end many new and useful tables. To the many who have come to regard Houston's *A Treatise on Light* as a standard text, the new edition is a pleasant surprise.—*H. H. Nielsen.*

A Treatise on Light (7th Edition), by R. A. Houston. xi+527 pp. London, New York, Longmans, Green and Co., 1938. \$4.50.

Quantitative Analysis

The educational philosophy of this book is contained in the following quotations from the preface. "It has been the aim of the authors, in preparing this work, to apply the principles of Physical Chemistry to the theory of Quantitative Analysis in a detailed and thorough manner. In stressing this point of view, it has not been forgotten, however, that the two other aspects of the subject, namely, technique and methods, play an equally important part in the education of the analyst."

"The order of presentation has been carefully considered and is as follows: (1) precision, (2) weighing, (3) measurement of volumes, (4) neutralization, (5) solubility product, (6) oxidation-reduction, (7) electrodeposition, (8) evolution and measurement of gases, (9) electrical conductance, and (10) photometry." The historical division into gravimetric and volumetric methods has not been employed.

This is an excellent book. It contains a full measure of theory and the techniques and details of the methods of analysis are well done and are accompanied by numerous citations from original papers. At the end of each chapter is a list of problems. There is a special chapter on organic precipitants and solvents and a long chapter on photometry. This last is mostly theory, and seems out of balance with the rest of the book. In the opinion of the reviewer the general techniques and methods of colorimetry and turbidimetry would have been better than so much theory. However, the reviewer heartily commends the book to students of analytical chemistry.—*C. W. Foulk.*

Inorganic Quantitative Analysis, by Harold A. Fales and Frederic Kenny. Second edition. xiii+713 pp. New York, D. Appleton-Century Company, Inc., 1939. Price, \$4.00.

Colchicine and Polyploidy

The first paper on the use of colchicine in producing polyploidy in plants was published by Blakeslee and Avery in 1937. Because of the great possibilities, which the use of colchicine promises to the plant geneticist and plant breeder, interest in the nature of colchicine and its effects on plants has become widespread. Within the last two years dozens of articles have appeared dealing with colchicine and artificial polyploidy.

A new pamphlet has been published by the School of Agriculture of Cambridge, which summarizes our present day knowledge of the action and use of colchicine in the production of polyploid plants. A bibliography of the literature on colchicine is included. The pamphlet is a sequel to a former pamphlet entitled "The experimental production of haploids and polyploids." Both pamphlets are valuable references for the plant geneticist and practical plant breeder.—*D. C. Rife.*

The action and use of colchicine in the production of polyploid plants, by J. L. Pyfe. Imperial Bureau of Plant Breeding and Genetics, Cambridge, England, 1939.